Testing Boundaries: A Theory of Adaption and Framing Effects in Ongoing Tasks

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Abstract

This thesis investigates how information presentation affects decisions in ongoing task scenarios. For this purpose it re-applies the principles of bounded rationality and specifically framing effects into this domain. Over a number of studies, unique properties concerning both frame effectiveness and additional measures such as confidence are observed to occur. A theory of cognitive adaptation to novel scenarios, and a re-defining of the concept of framing effects are proposed as a result.

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It is a cliché that a PhD thesis owes its existence to more than just one person. But it is a cliché because it is true, and this thesis is no exception to that rule.

I wish to thank my parents, for being supportive without question throughout this process with its many ups and downs. And more than that, for the unconditional love, support and commitment that started when I was born and hasn't faltered since.

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CHAPTER ONE - Decisions, Decisions, Decisions

A fox and a scorpion met at the bank of a river. "Carry me across", said the Scorpion. "No" said the fox, "Because you are a scorpion; if I carry you, you will sting me and I will drown". "But why would I do that?" asked the scorpion, "We would be in the middle of the river, and I would drown also."

Convinced by this argument that the scorpion would not harm him, the fox let the smaller creature on his back and started across the river. At the midway point however, the scorpion stung him. As poison filled his veins and he started to drown he managed to ask, "Why? Now we are both dead!"

"Because it is in my nature," the Scorpion replied.

Why Decisions?

The choices we make, and the reasons we make them have fascinated people since the start of recorded history. In the above fable, choice is seen as predetermined; we act not because we choose to, but because we are defined by what we are and must act accordingly. Conversely the heroes of literature, stage and screen are perpetually struggling to make the right choice, to act against their nature and defy what seems to be predestined – from *Romeo and Juliet* defying the expectations of their families and paying the cost, through to Harry Potter seeking to deny the prophesy that he would die at the hands of Voldemort. The struggle to determine our own lives through actions we decide upon is a recurring theme of human existence.

Decisions define our lives. Where we go, who we talk to, what we eat, drink, read and watch. Even when we complain that our lives are decided for us, that we have no choice we are at that moment *choosing* to voice that frustration. And we are *choosing* the path that seems immutable, to live up to responsibilities as a parent or to not start our own business. As bad an idea as the alternative might be, we still have the option of pursuing it. If we do nothing else in a day's span we

choose an answer to that most fundamental of questions: whether we continue on living or decide to end it all. It is a common complaint that we have no choice, but this is rarely true in the strictest of senses - having no good choices, or only one viable option is not the same as having no choice to make at all.

And so continually through our existence we make the distinctions and divinations that define our pathway. Even if we walk the path that a thousand have trod before us, we find our own route through that familiar landscape, or we choose not to deviate and allow previous experience to guide us forwards. The act of making decisions should be as familiar to us as breathing, and yet despite our lifetime of experience with constant choices we remain fascinated by them. We read autobiographies by famous people to try to answer the question of how they got to where they are, and what decisions bought them to that point. We demand interviews with figures of public note, to understand their motivations. It was not enough for the world to know that Tiger Woods *had* cheated on his wife; we had to know *why* he would do it. Endless articles speculated on this seemingly inexplicable choice that had no direct effect on the lives of most of people trying to understand it. When acts of unspeakable evil are perpetrated and terrorists kill innocent civilians, or gunmen attack students in their classrooms, we repeatedly ask *why*, what could motivate such an act. Entire works of literature are centered around difficult choices, of moral dilemmas and how they are resolved or addressed. Even when the decisions are objectionable, when the outcome is horrendous we seek to understand what could drive a person to make those choices, to bring their life to the point where that was a plausible route forwards.

And this interest is not simply internal, or theoretical. People have been interested in the idea of artificial life and thought through the ages – from the golem of Jewish folklore to the robots of science fiction(Asimov, 1950), the question of an artificial intelligence has often been used as a means to hold up a mirror to ourselves. In research it has often been the other way around – where any artificial systems are inevitably judged against the effortless and seemingly simple way normal people can make decisions and judgments. These properties

still escape our general ability to even explain let alone replicate in artificial systems.

Our understanding of our own motivations and decision making is often frustratingly poor. Most people know the feeling of asking themselves 'why did I say that?' after an exchange has gone badly, and not having any good answer for it. We make any number of decisions in a day with no good reason to justify it. If a person is asked why they had a certain food for lunch, the answer will almost inevitably be something along the lines of 'because I fancied it' which is a tautological non-answer. People make New Years resolutions in their millions, and a common experience shared by almost all is that of failing to keep them. We know that we want to live a different way and we choose on a larger scale to do so, but then fail to uphold that decision on a day-to-day basis. Why?

It is a commonly held belief that it is logic – formal, rational, an empirically justifiable explanation of reality - that drives our choices. We choose to do something because, logically, it is what we should be doing. It is the best way to achieve our goals, the most likely way to attain a favourable outcome and we are driven to make rational, reasonable discriminations between the available options. Most people like to think of themselves in this way certainly, and when asked to defend the choices made, they will generally respond along those lines – 'it seemed like the right thing to do'. But of course, we are anything but logical in our choices and life decisions. Anybody who has ever been romantically involved in any way can testify to the money, time and effort that is spent in the pursuit of something that is often unattainable for any number of reasons, or even an actively bad and destructive idea. We frequently make choices not because they are logical but because we believe them to be 'right'; because we value keeping our word, or the sanctity of human life. We even make decisions for no logical reason at all – a 'hunch' based on circumstantial, spurious evidence. Many great detective stories play heavily on this familiar sensation, with a lone detective following their gut instinct when all logic would insist otherwise. But such decision making is hardly restricted to the pulp thriller – if you ask most people how they pick lottery numbers they will answer with some variation of 'children's birthdays, significant dates, age, house I grew up in…' despite the fact

that this methodology has no greater acuity or likelihood of success than random selection.

Although logical thinking is often seen as 'correct' and what we should desire to perpetuate, there are actually significant drawbacks that make the ability to skip purely logical reasoning beneficial. Pure logic is frequently inefficient and time consuming, not to mention potentially hazardous. If a person gets sick after eating a particular food they will often avoid that food in future – even though logically they do not know if it was that particular item or the foodstuff in general that caused the illness. But in practical terms, the risk of getting sick again is enough of a deterrent that the cost of testing the hypothesis logically is not worth the price paid. In important decisions, time is often at a premium, and unknown and unreliable information proves a barrier to any purely logical solutions – here guesses, heuristics and rules of thumb come into their own. Commonly we fall back on cheap and dirty means of getting to an approximate answer that is good enough to solve the situation at hand and move on. In a game of football a player might not know exactly where his pass will end up, or where the other players will be when it arrives there, but he will make it when he has space and the need, because the alternative is getting tackled and losing possession. It is this sort of thinking – on the fly, in the middle of a strategic task where information is both plentiful and sparse, and a choice is informed by both what has gone before and is yet to come. How is it that we can pick up the basics of a game simply from watching it played? Or start to adopt the correct norms in an unfamiliar society unconsciously? Doing something we have experience of is one thing, but how do we approach those tasks that we have no prior knowledge of and yet manage to correctly apply experience that is somewhat related?

Logical reasoning is easy to explain, understand and study, relatively speaking. There are certainly complexities to it (many of them) but the fact that it works through solid rules and metrics helps to define it as a methodology that can self-evidently be expanded on its own terms. Guesses, hunches and heuristics are harder. There is not a single term to describe what they cover, and how and why the conclusions they offer are arrived at are harder to quantify. They vary, by definition, by person, experience, context, and others. But they are also powerful

and help to define the abilities that make people so good at choosing, adapting and advancing in new and novel tasks. Complicated as the process may be, years of previous research into it and similar problems suggest that it can be comprehended, that elements of this understanding can be mapped and defined and put to greater use. In particular, we can start to understand what elements of a new task we can gather from context, and how that context shapes our approach to it.

The Science of Decision Making

For a concept and a topic that is clearly so fundamental to our existence and laced with so many interesting questions and issues, decision making is a topic that presents a number of challenges to any attempt to study it scientifically. The preceding section illustrated the complexity of the area, and it is in this complexity that the scientific problems emerge.

From a top-down viewpoint, reductionist approaches inevitably represent a simplification of that complexity. Trying to narrow down the elements of decision making to their constituent parts loses the interactivity of those very parts and removes the very phenomena that were under study. Initial work in the area of Artificial Intelligence (AI) showed the limitations of this sort of approach. It was assumed that simply rule-based modelling could eventually account for all behaviour, but it was never borne out (Dreyfus, 1972). Similar problems were found in psychology when the limits of behaviourism in explaining complex behaviour were exposed, most notably in the area of linguistics (Chomsky, 1959).

Conversely, however, bottom-up approaches have a different set of problems. Although they present an obvious place for the individual units of cognition to be modeled – in the neural net that makes up the brain and presumably generates the mind – how it works remains fundamentally out of reach for modern techniques. The basic interacting parameters of the brain as a whole have not been established, nor those of interacting neurons (although progress has been and is being made). Still, there remain several levels of abstraction between the activity of neurons and a functioning decision making autonomous mind. And

approaches that attempt to model the intermediate stage of cognitive architecture have much the same problem. They raise questions about if any model accurately represents the process occurring, as opposed to simply replicating the pattern of activation.

It might be imagined that the appropriate reaction at this point would be that no approach can accurately study the phenomena, but this would be to miss the larger picture. All of the approaches detailed above have provided and continue to provide valuable insight into the overall picture. Top-down approaches begin to map the outcome space and provide insight for cognitive architecture. In turn, this suggests possible activation patterns to study for in neuroscience, that tests these hypotheses, and feeds back into the other approaches as well as inspiring new ideas for autonomy and so forth. None of the approaches *alone* can account for such a complex idea, but *together* the disparate sources of information can start to build up an accurate picture. This thesis, being interested in the role of context in the process will come from a top-down perspective and seek to provide some insight from that position as it does so.

Structure

This thesis will address the problem of how context affects decision making, particularly information presentation in ongoing task scenarios. This chapter has hopefully provided some general background and rationale for the ideas that the rest of the work is now going to explore in a more scientific manner.

Chapter Two Will provide a more in-depth review of the relevant literature that this work has drawn upon, and start to bound the general problem, identifying where empirical work can usefully start to address this problem. In particular, the area of bounded rationality and framing effects will be considered as a medium for examining how context affects decision making in tasks. It will be suggested that it is necessary to redefine framing to address this problem, and a rough set of parameters to this end will be given.

Chapter Three will then cover an initial exploratory study utilising a modified version of the card game Solitaire as its experimental medium to see how

information presentation can affect decision making and strategic choices. General principles of the methodological approach being used are also explained, and an initial model of adaptation is posited.

Chapter four then utilises this understanding in the first full experiment. It again adopts a card-game scenario (although a different one, based on the card game 'Uno') as its medium and uses this to examine both decision-making adaptation in an ongoing task, and also how bounded rationality works in this novel construct - that it does, and that it also possesses some unique properties.

Having identified that there are unique properties to bounded rationality in an ongoing task that are reflected in the way that decisions are made, **Chapter Five** applies a different methodology and framing mechanism to the same concept, now utilising a narrative problem involving an outbreak of a virulent disease at a music festival. It introduces the concept of 'confidence' in decision making, and uses it to provide an additional dimension for analysis. Discovering that confidence is affected by framing, and that frame-position is also important, **Chapter Six** re-applies this understanding in another narrative task, this time in the domain of cyber influence. Further discoveries are made about the persistence of framing effects, both in terms of the decisions made, and how participant confidence is affected.

Finally, **Chapter Seven** summarises the findings from throughout the thesis. The model of adaptation is reconsidered, and in particular, the stages of formulation and integration are re-described in more detail based on the discoveries made. A theory of framing in tasks is laid out and a redefinition of framing is specified based on the evidence presented in previous chapters. The implications for how we make decisions are considered, and some applications and further work considered before finally concluding.

CHAPTER TWO - Literature review

The process of making a decision according to logical principles can be explained and rendered predictable and replicable with relative ease. However, at the same time, such a way of making a choice can be slow, over-cautious and inefficient in the real world, and does not reflect how most are made (Evans, 2005). The other side of decision making - quick and dirty methods, assumptions, heuristics and guesses – has been extensively studied, but there remain more unanswered questions about how it works. This is the side of decision making that this thesis will be addressing. This chapter will briefly consider issues of categorization and bias in human mental processes as a background to heuristic reasoning. It will then explore previous research into strategic problem solving before examining the theory of bounded rationality and framing effects specifically. An approach will then be outlined to utilize framing effects to explore how context informs decision making in ongoing tasks.

Categorization

Categorization is the process by which mental representations determine whether an entity is a member of a category (Medin & Rips, 2005). It is also one of the fundamental processes by which people understand the world. We grasp concepts through understanding how one thing is like another. This provides the foundation abilities such as making reasonable assumptions based on limited evidence or heuristics to determine a best path forwards (Vosniadou & Ortony, 1989) by establishing the ability to determine when something is 'close enough' to work. Since information is frequently incomplete or ambiguous, best-guess processes represent a majority of the decisions we make (Hogarth, 1987).

Exact definitions and uses vary by researcher and discipline, but it is generally agreed that categories are defined by concepts, and concepts are mental representations used to distinguish between categories. So the category of 'squares' is defined by the concept of 'having four sides' (Rosch, 2004). This can be something of a recursive effect, where the concept of one category is a category of its own and so-on. Indeed, in the example given there is a reliance on

the category of 'side' having already been established to define 'square'. The difficulty of precisely defining these ideas (and their interdependent, somewhat recursive nature) has been a source of frustration to researchers for many years. Their precise nature and boundaries have proved elusive to lock down, even as the underlying ideas appear fundamental to human cognition (Lakoff, 2004). The representation is intuitively appealing, and has been used as the basis for a number of models of knowledge structures such as the hierarchical representation proposed by Collins & Quillian (1969). This model incorporated elements of network modelling, but used categories and concepts as some of the basic building units. It was found to be an insufficient model to explain human memory overall – negative relationships are identified faster than it would predict, and there are reversals of the predicted category effect in some instances (dogs are more easily named as 'animals' than 'mammals' for instance) (Rosch & Mervis, 1975) – but it provided a starting point that has since been extended. It established that whilst incomplete, associations are a useful part of modeling human cognition.

Assumptions and Biasing

One of the natural consequences of categorization being part of the basis for human memory is that attributes that are associated with a group are applied to individuals – which can lead to incorrect assumptions and bias. A generally appropriate concept for the category 'birds' is that they 'can fly' – though penguins and ostriches do not follow this rule. This can lead to assumptions when making decisions. For example, when at an event such as a festival or race day most people will assume that someone wearing fluorescent clothing is an official that they can ask for information such as directions. This is not necessarily true - anyone can buy such clothing if they wish to, and there have been examples of where this has been employed in order to fool people and commit fraud. It is an example of how context and over-categorization can lead to incorrect assumptions, but also how such assumptions are *generally* accurate, and thus why we use them.

As experimental demonstration of this type of tendency, researchers sent equally qualified CVs with different names attached to them to a large number of companies in the US. They found that regardless of which CV the names were attached to, applicants with 'black-sounding' names were less likely to be offered an interview than those with 'white-sounding' names (Bertrand & Mullainathan, 2004). Similarly, among mental health professionals where it is expected that diagnosis would be purely objective and evidence-based, there has been evidence of class-based discrimination with lower-class patients being prescribed more severe psychiatric disorders than middle-class counterparts (Routh & King, 1972). The fact that this difference is possible is at least in part due to the fact that psychiatric disorders are more reliant upon the judgment of the practitioner, but it still illustrates how an implicit bias can affect decision making. In both cases the people making the decisions in the studies rejected the idea that their decisions were being made on anything other than the facts provided, but the actual results illustrated an underlying bias. This can be explained as a consequence of how people manage knowledge and a result of categorization, and also illustrates why context can be important to the outcome of decision making even when the information might seem extraneous or unrelated.

Bias can also derive from heuristic reasoning. Once such example is confirmation bias - the tendency to seek to confirm rather than disprove a belief. When people with strong opinions on the death penalty were given the same fabricated studies to rate for accuracy and information, they rated the information that confirmed their prior belief as more convincing (Lord, Ross, & Lepper, 1979) despite the fact that all the information was untrue. A more direct example of this is the Wason card task (Wason, 1966), in which participants have to test a rule to see if it correctly describes a set of cards which have numbers on one side and letters on the other. Logically participants should seek to attempt to disprove the rule, but instead they tend to positively confirm it – which will not actually inform them if the rule is true or not. An interesting follow up to this finding, however, is that participants increase their ability to find the correct

answer (up to about 80% from around 20%) if the problem is coached in real world terms. Again context can be seen to affect how the same problem is solved.

Strategy and Planning

That context can affect decision making and the processing of information is clear from above, but raises the other half of the question; what about strategy? In the context of this work, strategy will be taken simply to mean planning and decision making for a task that goes beyond a single decision point. This area is less well defined and empirically accounted for.

Strategy has been described as a function of stimulus detectability, where once a stimulus is detected (generally against a background of experimental noise) it prompts a particular strategic response in the form of a particular schema being enacted (Tanner & Swets, 1954). This has been supported for a variety of simple cognitive tasks as well as some more complex ones such as choice reaction (Sperling & Dosher, 1986) and provides a decent account of action-level strategic activity. It does downplay the internal deliberative process however, and relies heavily upon timing responses to stimuli for evidence - measures that become less reliable or important where more complex decisions are necessary. For this reason this thesis will be concerned with higher-level problems.

Extensive use has been made of games in studying ongoing problem solving, although these have their own limitations. Generally these problems are 'solvable', where a particular strategy can be quantatively established as optimal. Connect Four was solved as part of a masters thesis for instance (Allis, 1988). Similarly, whilst chess has thus far defied any such full account, the best human competitors have been beaten by artificial counterparts who draw primarily on advanced search principles such as the SUPREM architecture (Berliner & Ebeling, 1989). Impressive as these developments have been, however, they utilise search trees, and exploit the fact that the environment they are working in is limited, definable and therefore can be accurately modeled with little ambiguity. Solvable problems do not necessarily represent the sort of problem encountered in the real world, nor the manner in which a human approaches them. This thesis is concerned with situations where there either is no

solvability, or it is impractical to determine, and the strategies that exist in human cognition to cope with that. There is evidence that people do show some of these same characteristics as the solutions proposed by solveable problem models, with increasing skill associated with increasing search depth in human players (Gobet, 1997). However whilst this can account for aspects of human problem solving, it fails to capture the whole process. A study comparing different types of instruction (conceptual verses procedural) for chess novices did find that it was conceptual knowledge that left participants better prepared to find solutions for mate problems (Marmeche & Diderjean, 2001), providing some evidence that it is the ability to understand a problem rather than just memorize the necessary components, that allows adaptation to a new problem. If optimized search methodologies were all that was required, procedural information should have also proved equally useful.

In trying to represent human decision making, a common approach has been to define the process as a series of parts, particularly in management studies (Kepner & Tregoe, 1965) – analysis, identification, causes, objectives and so forth. But these approaches are limited by the fact that they are generally attempting to replicate 'correct' decision making and provide a prescription for other people to follow rather than an account of cognitive architecture. More generally, when problem solving, people are seen to adopt basic strategies or plans when approaching a problem that are then modifiable on contact with new information. This formulation was part of the basis for ACT-R, an action-level account of cognitive architecture (Anderson, Matessa, & Lebiere, 1997) which has since been extended and built upon extensively. Adopting a new rule supplied by a hint can be observed and modeled (H. A. Simon & Reed, 1975), as can the easing of difficulty once a particular skill or rule is internalized (Kotovsky, 1985). But even here, the importance of context is still present. Domain specificity is a well established phenomena where the solution that is obtained can rely heavily on the context in which the problem is posed (Hirschfeld & Gelman, 1994). The theoretically same abstract problem can be either easily solved or almost impossible depending on whether people have experienced that particular context before. This also extends to creativity, with

the work produced varying in quality and quantity according to the domain in which a question is posed (Reiter-Palmon, Illies, Cross, Buboltz, & Nimps, 2009) in a setup where there are no 'correct' answers. Formal models of problem solving such as ACT-R do not provide accounts of this property.

Situated Cognition & Problem Isomorphs

Situated cognition is defined as differences in response that can be observed due to environment (Kirsh, 2009). It does not attempt to model the internal processes of a problem solving approach, but rather that how a problem is solved (and how a 'problem' can be defined) is a function of the context in which it is found – physical, social and more. It argues that the mental approach to situations cannot be represented simply by relating them back to abstract principles but are grounded in the situation they are found.

A famous example of this concept is a study on Brazillian street children, who had developed particular domain specific procedures for mathematical functions, and found it hard to transfer this understanding to more formalized mathematical settings (Carraher, Schliemann, & Carraher, 1985). A similar example found milkmen made use of the physical shape of the containers in which they delivered milk to do calculations and again found it difficult to do equivalently difficult calculations out of this context (Scribner, 1984). Both of these examples demonstrate how problem solving is not necessarily reduced to a consistent abstract representation that is then re-applied as appropriate. If it were, both example sets of people would have found it as easy to do calculations out of their familiar context as they did within.

The degree to which cognition is situated or internal and abstract is a matter of continuing research, but the idea that people's mental processes are affected by the world around them is broadly supported by a variety of research. Human Computer Interaction as a discipline and usability specifically has demonstrated that performance can be affected depending on how displays are organized, for instance in ambulance dispatch displays (Moore, Hayes, & Wong, 2013) or how mobile phone interfaces affect user satisfaction and efficiency (Kim, Proctor, & Salvendy, 2012). The concept of affordability and usability rest on the idea that

certain contexts support efficient human cognition more than others (Norman, 2002).

Problem isomorphs are an example of problems that touch on both strategic problem solving, and situated cognition. Problem isomorphs are superficially different representations of logically equivalent problems (Kirsh, 2009). However, these superficial differences have been found to affect people's ability to reach a solution. The Tower of Hanoi is a logic problem that involves attempting to move a set of items from one location to another whilst abiding by rules that govern how those items can be assembled in a given location. In the classic example it consists of a stack of three items that need to be moved from one location to another. Only one item can be moved at a time and there is only one intermediate space available. It has been found that different isomorphs of this problem (where the items are not necessarily ordered by size but by other properties following the same rules such as number or colour instead) take significantly different numbers of moves to solve (Kotovsky, 1985). This shows context in the form of problem representation affecting how a problem is both perceived and approached even though the abstract logical task being performed remains the same. Similarly different interaction constraints on the same logical problem have been found to affect problem solving although the logical information available through those interactions remained constant (Dou, 2010). Representations of the same puzzle in different domains have found to affect problem solving likelihood significantly, with physical and digital representations affecting performance, and even different digital representations (Kotovsky & Simon, 1990). Again, this points to situated cognition and context having an effect, as even the difference between being able to hold something in your hands or making changes to the same problem represented on a screen matters. The effects of isomorphism are also not limited to differences in how a task is represented. Instructions that convey equivalent information have also been shown to create performance differences in different tasks on the same tool (Bibby & Payne, 1993). Different groups were shown to perform better in different tasks depending on which instructions they received,

indicating that instructions can affect how knowledge is represented in the mind, and thus how easily certain tasks are performed.

This work is not without its limits however. Work in this area to date has again relied upon 'solveable' problems to create isomorphic equivalents. These are task scenarios with definable ends states and limited action possibilities specifically chosen so that equivalences can be created and manipulated. In many ways this focus is simply reflective of a requirement of isomorphism, and problems cannot be shown to be isomorphic without being controlled in such a manner. But many real world problems are not solveable in this way and do not necessarily even have an end state, or parsable processes and stages to be quantified. These can still involve strategic choices and different representations, but cannot be so easily controlled and balanced.

What the literature on problem isomorphs illustrates, however, is that logical approaches and strategic choices can be affected by the context in which they are presented. It therefore seems likely that this is true for problems that cannot be quantified in such a manner as well, although a methodology is required with which to approach them.

Bounded Rationality

Bounded Rationality was first proposed by Herbert Simon (H. Simon, 1957), and proposes that rather than being inherently rational actors (as many models of human behaviour and decision making in a variety of disciplines have done) people act rationally within the bounds of their comprehension of the world – bounds such as cognitive biases, perceptual limitations and comprehension failures. Bounded rationality is not concerned with how information itself persuades a decision maker to one set of actions or another, but rather how the bounds that that participant are in are responsible for the variability that can be observed(Gigerenzer, 2008). What this means is that there is a body of work that exists already establishing different conditions which are known to affect particular decisions without altering the informative content available to decision makers.

Systems One and Two

Bounded rationality is generally seen to operate as part of a dual-system model of human decision making. These are referred to as system one and system two, and reflect different aspects of the decision making process, a distinction originally coined by Stanovich and West (Stanovich & West, 2000). These are summarized by Kahneman (Kahneman, 2002) as:

System one is the quick, instinctive decision making system. It is described as fast, automatic, effortless, associative and slow-learning.

System two is the time consuming, conscious decision making system. It is described as slow, serial, controlled, effortful, rule-governed and flexible.

These systems are not an either/or model. Whilst some questions may use one more than the other, they are thought to constantly interact, and one of the roles of system two is to provide explicit monitoring of system one (Gilbert, 2002). In different situations one system will take priority over the other even though the other is still active. For example, if a person is asked what 1138 + 435 is system two will take priority as would be expected. However, if asked to decide between 1600 and 2300 which is *closer* to the correct answer for the same question, system one will allow most people to answer 1600 as it 'feels' more correct.

These systems are the basis for the bounds of bounded rationality. They describe how the first system in particular is affected by the constraints that surround it, and then also how the two systems with their different methodologies and strengths interact – when, where and how.

This hypothesis has been put to extensive use within the field of decision making. It has been used to provide insight for marketing, explaining patterns of buying on the stock market and persuasion in politics (Myers, 2002). There has also been some support from it within neuroimaging scans, where particular activation patterns have been found for gut feelings and insight (Bowden, Jung-Beeman, Fleck, & Kounios, 2005). Other work has found activation in the median orbito-frontal cortex (which receives input from all over the brain and thus is a plausible location for assembling disparate sources) and the amygdala (which is

the center of emotions in the brain and therefore related to the emotional component of system one) in studies of instinctive guessing, providing a neurological basis for the distinct systems (Volz & Cramon, 2006). Therefore, the two-system hypothesis has a reasonable grounding in both practical application and in theoretical neuroscience structures, which in turn raises the question of how bounded rationality can help to explain human behaviour and further this work.

Prospect and Utility theory

As an example of how bounded rationality can explain decision making we can use the example of prospect theory and how it has extended (and to some degree supplanted) utility theory.

Utility theory is a theory which models how choices should be made, based on a set of logical axioms (Myers, 2002). It has provided the basis for a lot of economic theory, as it is assumed to not only detail how decisions *should* be made but also how they *are* made. It assumes that there is mathematical parity between the relative falls and gains in wealth and that wealth's perceived utility or value, as well as the value of various objects. If a person is offered a choice between a cup of coffee and a cup of tea and shows no preference, for instance, then they would also have no preference between the choice of a 40% chance to win a cup of coffee, and a 40% chance to win a cup of tea. If they liked the taste of coffee, but not tea then they would similarly prefer that chance over the other.

However, as we know, people do not always make decisions based on strict logical probability. Consider a bet where a coin is tossed. A choice is offered between either winning £100 if the coin comes up tails or taking £46 for certain (Kahneman, 2011). Most people will take the sure thing, despite the fact that on a statistical level the chance is actually more rewarding. Consider also if this bet was offered at the level of £1 if the coin comes up tails or 46p for sure – more people would now be willing to go for the chance. Finally, imagine if the same conditions were offered, but the levels were now £10,000 or £4,600 – even fewer people would now be likely to take the bet rather than the sure thing.

The explanation given for this in utility theory is one of psychological intensity. Rather than being calculated purely on the merit of statistical likelihood, people evaluate these bets based on the intensity of the options weighted by their probability. What this means more simply is that the difference between 46p and £1 is not actually very much because neither is that valuable and neither is that different from the baseline state of zero. Hence, the chance is not seen as that important. However, when the stakes are raised to £10,000 and £4,600 suddenly the psychological intensity of the stakes are much higher and the chance is much more of a risk, so people will defer to the sure thing with increasing likelihood. This is the core of utility theory; the value of a bet or proposition can be objectively calculated according to the values within.

This theory was, and to an extent is, still the basis for economic theories of value for many years, but it lacks a basic factor that would alter many of its predictions – reference points. This flaw was first identified by Kahnemann and Tversky, who pointed out that it is not simply the utility of wealth that drives such decisions, but also where a person starts (Kahneman & Tversky, 1973). It is this observation which forms the basis of prospect theory.

To illustrate this, consider another bet: Winning £2 million guaranteed, or a 50-50 chance to win either 4 million or 1 million. The utility of these two propositions is equal, and it would not be surprising to see a person pick either one or the other – the increase in utility between 1 million and 4 million is not actually that much.

Nevertheless, now consider the two people to whom this bet is actually offered. Jack has 1 million to start with, and Jill has 4 million – and in participating in this bet they have to stake their current wealth. The utility of the propositions remains exactly the same as before, but the context has changed massively. For Jack the bet is essentially a no-lose scenario – he cannot exit with less than he started off with, and whilst both propositions can offer him more, the chance offers more. In the worst case he is where he started. This makes him more likely to risk the chance. He is primed to engage in risk-seeking behaviour.

Jill on the other hand is mostly certain to lose something. At best she could preserve what she has, and in that case she would be as likely to go down to 1 million. From her perspective, she is looking to minimize her potential losses and is therefore more likely to go for the 2 million guaranteed. She is primed to be risk-adverse.

These positions are supported by empirical testing putting participants in those virtual roles. What is important about this result is that the starting position of the two participants changes their approach to the problem, despite the fact that their potential outcomes are identical (Kahneman, 2011). Their prior positions should not matter due to the utility of the options, and logically they do not, but when people are involved the calculations do change. Context affects choice when the choices themselves are perfectly balanced. This is the core of prospect theory – that it matters where a person starts from.

Another example of this principle is to consider another pair of people, George and Vicky. George has 8 million pounds, and Vicky has 2 million; both invested on the stock market. As a result of a volatile day, Vicky and George now both have 5 million. Who is happier? Naturally we would say Vicky, as her wealth has increased by three million, whereas George's has decreased by the same amount, but their actual value is equal – by utility theory they should have the same satisfaction. What is occurring here is that they are exhibiting risk aversion, where people are more sensitive to losing what they already possess than they are to gaining additional things (Novemsky & Kahneman, 2005). Again Utility theory would treat these as equal propositions, but prospect theory recognizes the importance of the starting position to the psychological evaluation undertaken and better predicts behaviour. It is not necessarily in effect all the time: if instructed to 'act like a market trader' participants show less loss aversion which suggests it is a function of system one and can be selectively applied (Sokol-Hessner et al., 2009). Some evidence has been found for this tendency to be neurologically based, with a broad set of gain-sensitive areas (including midbrain dopaminergic regions associated with reward mechanisms) showing less activation when potential losses were contemplated (Tom, Fox, Trepel, & Poldrack, 2007).

The key relevance of this example for this thesis is that the starting point matters to the perception of gain or loss. Context will colour a person's perception of a gain/loss event, and thus presumably affect their reasoning when considering what to do next.

Framing Effects

A particularly useful component of bounded rationality for the purposes of this work is framing effects. Framing effects are where the same useful, informative content is presented in different ways in order to induce a user towards a particular choice (Gigerenzer & Selten, 2000).

Consider a university Engineering department whose intake of undergraduates was split into 20 girls and 48 boys, with the year having just passed. Their new intake this coming year will be 30 girls and 45 boys. This could be expressed as 'The proportion of girls taking Engineering has increased'. Alternately we could say 'The proportion of boys taking Engineering has declined'. Both statements would be true, and both would be logically the same thing, containing the same information about the world, but they *feel* very different statements when read. To hear about more girls taking engineering might summon up satisfaction that a long-present gender gap was apparently declining. To hear that fewer boys were taking the subject might raise concerns that they are falling behind their more studious feminine counterparts.

This is an example of a frame. The same logical information is imparted: a person who reads either of the two statements will have the same level of knowledge about the state of the world logically speaking, yet vastly different perceptions of what is going on in the world of engineering.

Perhaps the most famous example of a frame is that of the Asian flu experiment (Tversky & Kahneman, 1981). In this example, participants are presented with a choice of two responses to an outbreak of Asian flu in a population of 600 people. They can either guarantee that a certain number of the population will survive and a certain number will die, or they can take a probability that the entire population will either live or die. These are expressed as:

Formulation One:

> *If Program A is adopted, 200 people will be saved.*
>
> *If Program B is adopted, there is 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved.*

Formulation Two:

> *If Program A is adopted, 400 people will die*
>
> *If Program B is adopted, there is 1/3 probability that nobody will die, and 2/3 probability that 600 people will die.*

Note that between the two formulations the actual logical information being presented is the same. Also note the between the two programs the statistical value of both is actually identical – if the situation was run 100 times and the same program was picked each time, statistically speaking the same number of people would be expected to survive and die in each choice.

It was found that in formulation one, 72% of participants chose program A. In formulation two, 78% of participants chose formulation B. It is suggested that the reason for this is that the framing alters the type of decision being made. Formulation one supports a risk-adverse (see earlier) decision – participants chose to be sure of saving 200 people. Formulation two on the other hand supports risk taking – the 400 people dying for certain is regarded as less acceptable than a 2/3 chance of everyone dying. The frame is therefore priming different sorts of a risk-taking heuristic through the way the information is structured. Context, again, is driving the manner in which a decision is made.

Framing has since been applied to a range of circumstances to either explain decision making, or to illustrate that the process is not as objective as we might imagine. It has been demonstrated using mortality rates to affect the decisions of doctors (McNeil, Pauker, Sox, & Tversky, 1982) and richness of a description to affect a court decision (Shafir, 1993) for example.

The effects of framing are not immutable and unmoved by other factors however. Individual differences can play a role for instance. Framing monetary

gains or losses can normally prime an individual to be risk adverse when a choice is framed as a gain, but risk adverse when the same decision is framed as a loss (Kahneman, 2002). However, recent work has found that whilst older participants do become risk adverse when a standard gain/loss gambling task was framed as a gain, they do not show risk-seeking behaviour when the same task is framed as a loss (Mikels & Reed, 2009). Similarly there is some evidence that experience can prevent a frame affecting a decision. Invitations to register for a conference were sent to all people who submitted a paper for an economics conference, but the description of increasing fees as the deadline neared were framed as either a penalty for being late, or a bonus for registering early. When divided by experience level, junior experimental economists registered in greater numbers when the change in prices was described as a penalty, whilst their senior counterparts showed no difference between the two conditions (Gächter, Orzen, Renner, & Starmer, 2009). The experiment is notable for establishing that a frame can be effective in a real world setting, and also for showing that experience may cause people to be less susceptible to framing, although it should be noted that this may represent *knowledge* of frames, given that the subject pool was economists who would be expected to have a high rate of knowledge of the subject. Regardless the fact that it was effective on the junior subset (who should also have this domain knowledge) suggests that a broader effect may be at play. In a laboratory based experiment, differences in choices made were found to exist between sexes. Although both sexes were framed, they responded at different rates to framed decisions in different domains such as money vs time and life vs death domains (Huang & Wang, 2010). Again this result is somewhat ambiguous for where the reason for the difference comes, and it is reasonable to suggest that social cues which set different priorities for the different sexes may be responsible rather than fundamental processing differences between the sexes. Regardless, these studies illustrate that pre-existing knowledge and experience can have an impact on how participants respond to framing, regardless of the source of that information.

There is some limited evidence that framing can occur in an ongoing tasks as well as single decision point, and then be affected by additional factors. These

experiments do tend to have a very limited scope for what comprises an ongoing task. Bounded rationality has been applied into the area of strategy selection, particularly with the suggestion of cognitively bounded rational analysis (Howes, Lewis, & Vera, 2009). This provides an account of cognitive architecture in psychological refractory period dual-task performance and illustrates the potential application of bounded rationality into cognitive areas, but that strategy selection account is at the cognitive level where context is invariant; this thesis is concerned with activity when the context in which a strategic decision is being made varies. In an online shopping task where offers and price reductions were framed, messages that warned against bias successfully lessened the framing effect in highly engaged participants (Chenga & Wu, 2010), although the effect was lessened both by the intensity of the message decreasing, and by the participant being less engaged. Regardless, a small-scale task was successfully framed, and that frame was subsequently counteracted. In a 20-day simulated stock-buying simulation where participants rated their emotional state as the task was conducted it was found that affect attenuated framing effects (Seo, Goldfarb, & Barrett, 2010). This both again successfully framed a task longer than one decision (albeit in a highly limited and artificial setting) and linked framing effects to another cognitive characteristic, in this case emotion. In a complementary study, risk-loss framed gambling task participants were prompted to use cognitive reappraisal techniques to regulate their emotions whilst performing the task, which also reduced framing (Miu & Crişan, 2011), suggesting that the emotional component might not just be attenuating framing but actually driving it.

The significance of these findings to this research is that framing is a complicated and involved process, one that is potentially not easily divorced from the context in which it occurs, as theories of situated cognition would suggest. The dimensions of what can affect framing, and be affect by framing appear to potentially be broader than simply what decision is made. Framing therefore potentially represents a methodology with which to systematically vary how information is presented, and thus potentially affect strategic decisions – with that difference therefore being attributable to presentation rather than logical

content of the information. Research has demonstrated that framing can exist in tasks beyond a single decision, although as noted these tend to be very tightly controlled environments that lack the complexity to suggest that strategic decisions are being framed – the choices do not generally have ongoing consequences for instance. This offers a potential area in which to offer novel investigation.

Limitations of Framing

Framing as a theory has not been unchallenged however, and is not without its conceptual limitations. The assumption that underlies framing is that the two choices presented are equivalent (isomorphic) in their ambiguity, but there are suggestions that this may not be entirely supported. A review of the relevant literature (Kühberger & Tanner, 2009) suggested that the relevant choices in the Asian flu example are not equivalent, and that when ambiguity is equalized between the two descriptions, the framing effect is either significantly weakened, or disappears. An example of this is an experiment that transferred the domain of the asian flu choice, and controlled for this imbalanced ambiguity in the new context (Mandel, 2001). In this case, the framing effect was no longer present.

These finding raise a valid point – what exactly can be considered to be a frame? If the effects that have been noted are simply a case of unequal ambiguity then can framing be said to exist at all? The studies cited above find fault in the unequal distribution of ambiguity, but it is not necessarily the case that their defining it as such is appropriate. It is possible to control for framing by controlling the amount of ambiguity present, but the process of deciding what is or is not ambiguous depends itself upon a judgment call by the experimenter, and perceptions of what is ambiguous will vary between participants. But even accepting that imbalanced ambiguity may be the source of the phenomena does not invalidate framing as an approach. Real results and significant findings with applicable implications can and have been found.

Instead, framing may not be well served as being defined as limited to precise and strictly isomorphic equal pairs. The Asian flu example (Tversky & Kahneman, 1981) would no longer be an example under such a classification. If

such rigid standards are applied then it could become functionally impossible to define anything as being framing – some level of unbalance could be found in virtually any attempt to create approximately equal sets of information.

Such a stringent requirement would miss the point of framing on at least two levels. Firstly framing is clearly not solely defined by ambiguity. The studies presented in this review have identified a number of dimensions which can affect the decisions made even given these non-isomorphic sets. So they remain a viable method in which to identify additional factors affecting decision making. Secondly, the real world is a complex, dynamic and largely uncontrollable set of conditions. Understanding real world decisions may require accepting a degree of imbalance in methodologies. Framing may well not exist without a slight imbalance of ambiguity, but approximate ambiguity can create demonstrable results as listed above, and framing still provides a useful model for understanding those properties. But that said, it may therefore be necessary to re-define framing to allow for use in more complicated contexts.

Re-defining Framing

There are still unresolved questions to be answered about how task strategy in ongoing strategic tasks might be affected by information presentation. Bounded rationality provides evidence that context affects decision making. There are examples of work extending framing into ongoing tasks, but these have been tightly controlled, highly artificial examples where the strategic thinking does not reflect more complex, ambiguous scenarios.

Framing effect are still largely conducted in a single-decision paradigm, and as part of the re-defining suggested above it would be useful to move it beyond this paradigm. Kahneman has described such choices as being 'the fruit fly' of decision research (Kahneman, 2011), and it is an apt analogy on a number of levels. Single decisions are easily set up, quickly run and repeatable. They are also highly controllable and free of many extraneous variables – it was a relatively simple task to sequence the fruit fly genome. They can tell us a great deal about how we make decisions in the same way that fruit flies can tell us about genetics, but there are limits precisely because of their simplicity.

In the same way that fruit flies are a simple genetic blueprint to work with, single decisions are a simple paradigm to employ and both miss the larger picture. Humans are significantly more phenotypically complex than fruit flies, and decision making in the real world is significantly more complicated than single-decision tasks. But applying frames into a more complicated and ecologically valid context is not simple. Frames rely on precise construction in order to be considered isomorphic, but such tight definitions limit their applicability in a system where those basic constraints are more able to be challenged, contradicted or usurped. Approximate, rather than full equivalence may be necessary to assess framing in this context, but that is not an inappropriate methodology to apply – as has been noted even tightly controlled single decisions may not be equal in their ambiguity but they still represent a valid source of investigation, this would be an extension of that.

The question has potential implications for wider theories of bounded rationality and not just framing effects. The premise of systems one and two is, as previously noted, at least partially that system two has monitoring duties over system one (Gilbert, 2002). So at what point does the monitoring system cut in and override the emotional or gut decision that has been made as a task progresses? Some research has addressed the concept that monitoring can occur (Gigerenzer, 2008) but this has generally taken the form of priming subjects to respond to questions and considering them more consciously. Alternatively it has been shown that intelligence can be linked in certain tasks with a greater degree of system two control (Frederick, 2005), but again this is in a single decision task. There has been little attempt to determine how system two might gradually take back control from system one.

An objective of this thesis will be to provide a framework for better defining frames within a larger context. As noted, framing effects are generally reliant on tightly controlled single choice and limited context methodologies in order to be balanced, but such tightly controlled circumstances are too artificial for this objective. Therefore it will seek to re-apply more traditional frames and experimental paradigms as closely as possible whilst also expanding them to more closely resemble complex, ambiguous ongoing tasks, following a general

principle of obtaining as much approximate balance as possible. From these approximations, a more precise and quantified framework will be developed and suggested in the concluding chapter of this thesis.

CHAPTER THREE – Equivalent Rule Changes: The Solitaire Study

Introduction

The previous chapter established the existing understanding of framing in current literature, and illustrated the limitations of the current definition. Expanding the definition (and understanding) of this process is not trivial however - there exist a great deal of conflicting, possibly confounding factors within potential experimental designs.

The first study was designed as being solely exploratory in nature. A task was designed to be approximately isomorphic at the new rule implementation level and for the findings to act as a pointer for subsequent research. It was not designed to be perfectly balanced for the theoretical reasons detailed in the previous section; producing a direct isomorph of rule changes in a complex environment is extraordinarily complicated and potentially self defeating. A general hypothesis was therefore employed rather than specific predictions. It was hypothesized that approximately isomorphic rules would produce observable differences in behaviour.

The task was designed to contain an element of novelty in the form of introduced rule alterations, but familiarity in the underlying mechanisms and manipulations being employed. It was also designed to allow a degree of freedom of behaviour and choice, in order that alternative behaviours were possible.

Design

Measurements were kept general rather than tightly controlled or specific by design, as what should be observed was not yet established and the hypothesis was general rather than specific.

The study's environment was required to fit several requirements. It was intended to be a familiar task that was also modifiable in order to introduce the novel element. It would also need to be relatively controlled, with easily

identified and categorised actions and behaviours. Finally it was desired that it would be ambiguous, at least to the degree that optimal behaviour could not be easily and obviously adopted in order to be able to differentiate between different strategic approaches to the problem.

It was decided to utilise the card game 'solitaire'. Games present a controllable and constrained environment to study behaviour, where the limits and features of a system can be readily understood and accounted for. The paradigm also enables for the introduction of a new rule as a source of variation to a familiar environment.

A potential objection to this methodology is that the game is comparatively knowledge-light and solvable (in the manner that theories of situated cognition take exception to traditional limited-scope decision making experiments(Kirsh, 2009)). However, this is not considered problematic for two reasons. Firstly the task domain still represents a significant expansion of potential action. Secondly, whilst small changes to card games can potentially be made optimal it does not follow that they can be made optimal and implemented perfectly by a person - particularly not whilst playing the game for the first time. The changes are sufficiently complex that there is enough ambiguity for mistakes to be made and imperfect and variable strategies adopted. Additionally, the aim of this line of study is not to establish a best-fit solution for this game, card games or indeed games in general – but rather to understand the cognitive processes involved in reasoning for more complex situations. The methodology of going from encountering something new and then ending up at a solution are what is interesting, not the result itself. The process of developing a solution and to what degree it is primed by context is still relevant when obtained from an optimizable scenario, although the eventual intention is to understand it in terms of non-perfectible examples.

Method

Participants were pre-selected on the basis of having familiarity with solitaire simply by asking them if they knew how to play it. Otherwise, no criteria were applied to recruitment, other than availability.

Initially, all participants filled out a questionnaire that consisted of a Likert-scale set of questions rating their confidence in and level of understanding of games in general and solitaire in particular (see appendix one). They then answered a set of open-ended questions about the game designed to elicit knowledge about how the game worked and particular strategies, as well as general understanding of strategy and adaptation in their everyday life.

Solitaire

Solitaire is a single player card game that is also known as patience and familiar to a large number of people at least in part due to its inclusion as a free game in Microsoft windows operating systems since at least windows 3.11.

The game is usually played with a full deck of normal cards (Ace to King of all four suit), although for the purposes of this experiment it was played with Ace to Queen, as the removal of the Kings made the game marginally easier to play and quicker to complete.

Solitaire has a set of core mechanics, although there is some variance in how particular individuals play. There exist, for instance, multiple options for how many cards a player deals from the deck, and how many times they are allowed to cycle through said deck in the course of the game. The rules presented below and used in this experiment are one common instance of the options available.

Objective

The objective of a game of solitaire is to move cards from the playing area into four sorted piles of cards ascending from Ace to Queen in a given suit. These cards can be moved at any time from the play area, but must be moved in order, starting with the aces and continuing upwards. The cards can be moved back down once they have been placed in the winning piles to be used in the game again as part of a legal move, but only if they are the top card.

Setup

It was necessary to set up the playing area correctly before starting. Seven piles of cards were dealt onto the table in a line in front of the participant. From right to left these piles contained an ascending number of cards, from one on the far

right to seven on the far left. The top card of each pile was then turned over so that it was face up and left on top of the pile. The piles were staggered slightly so that it was visible how many cards were left in each case under the face-up card.

Above this arrangement of cards, four spaces were designated for cards to be moved into as part of the win condition of the game.

The remaining cards were placed face down on the table in front of the participant to serve as the deck from which additional cards would be drawn in the course of the game.

Play

Play proceeds with a participant making a legal move. There are several moves which are legal, and a player can perform any of these any number of times before choosing to do another. These move types are detailed below.

Deal – A player deals three cards in sequence onto the table, or onto previously dealt cards if it is not the first time that they have dealt. These cards are dealt face up. A player may then use the topmost card to make a legal move. If they succeed at this they can use the next card down, and soforth. If there are less than three cards in the deck, they deal as many cards are left and play from that. If there are no cards left to be played, the player picks up the pile of dealt cards and turns it over without shuffling and uses it as the deck to be dealt from once more.

Move – any card which is face up on the table can be placed onto another card on the table provided it is on the playing area. Cards cannot be placed onto the cards that have been dealt. The rules that govern which cards can be moved into the win piles have already been explained. Within the deck, card movement is governed by colour and number of the card rather than the suit. A card can only be placed on another card that is numerically one higher than it, and of the opposite (red or black) colour). So a seven of clubs (black) can be placed on the eight of diamonds (red), but the seven of hearts (red) could not. Nor could the six of clubs (black), which is the right colour, but wrong number.

If cards are assembled into a stack of cards in this manner, they can then be treated as a single card for the purposes of moving them. A stack that has the seven of hearts as its highest card can be moved in its entirety onto the eight of clubs – which may itself be part of a stack. These stacks can also be disassembled if it is desired, with any card from the stack able to act as the 'top' card for the purpose of moving them.

Cards cannot be moved as a stack up to the win piles, since obviously they break the rules of how cards must be placed in those positions.

If in the course of play the card that is upmost and face up on a pile of cards is moved away from that pile, the card underneath it is turned over to be face up and can then be played as normal.

If a pile of cards on the table is exhausted, that space is now open. Only the highest card (a Queen) can be moved into it either alone or as part of a stack, and the queens can be used normally from that point.

The game ends when either all the cards are in the winning position, there are no more legal moves, or the player decides to stop the game.

Video footage was taken of all the games played. Participants were instructed to play five games of regular solitaire. They were allowed to choose the point at which they stopped, either when they completed the game or found that they had no more viable moves to make. Before they started they were presented with standard rules, and also encouraged to ask any questions that the rules may not have covered to ensure consistency of approach. This was due to the high variability of solitaire rules and the prevalence of 'house rules' that are commonly used. Participants were filmed whilst undertaking the task, and encouraged to 'think aloud' about the moves they were making if they felt they had anything to note.

After five games they were then given one of two additional rules for the game:

- The **'FreeCell'** condition introduced a freecell such as those found in the namesake card game, where any one card could be placed and stored with no restriction (other than the requirement that it had to be permissible to

move the card in the first place). Once the freecell was occupied it was full, and no more cards could be stored there. Cards could be removed from the freecell at any point where a legal move was permissible.

- The **'Wild Sevens'** condition made added a rule specifying that, sevens were exempt from the normal rules of card placement. They could be placed on any card, and have any card placed upon them. However, if they were used in a manner that would normally have not been permissible no stack beyond one initial card could be placed on them.

These rules represented different methods of obtaining functionally similar changes to the game environment. In both conditions it was now possible to move cards outside of the normal placement rules.

Finally, once the games were complete participants were asked for their thoughts on their strategies when dealing with the new rules in a questionnaire (see appendix two).

Sorting and Coding

Multiple empirical measures were taken from the experiment, primarily from studying the videotapes retrospectively. From playback, the time of each move made was recorded and coded according to the type of action that was occuring. The codings used were as follows:

Uncover: A move where a card is uncovered, either turning a card face up on the board, or dealing cards from the pack

Normal: A move where a face up card is moved on the board of play, either from the pack, between cards on the board, or up to the finishing piles. Any card movement that could be performed under the regular rules, and in no way involved the new rules.

Special: A move where the new rules are being bought into play (moving cards to the freecell, playing a card on a wild seven)

Reverting: A move that takes a card currently positioned as a result of the new rules (in the freecell, on a wild seven) and places it back into regular play.

Pass: Where a new move was possible, but declined. Primarily coded for when sevens appeared in the dealing pack, but were not utilised (since they could be placed on any card, they are always capable of being used)

Non-Special: Specific to the Wild seven rule, where a seven is used in a manner that did not require the new rule (placed on an eight, for instance)

These codings were considered sufficient to cover the range of possible actions interesting to this analysis, without being so specific as to defy the identification of any patterns.

Participants

There were 6 participants in total, three in each condition. There were two women and one man in each condition. The mean age of participants was 24, and the median 23.

Results and Analysis

As the nature of this study was exploratory rather than hypothesis testing, the analysis focused on looking for patterns and trends in the data. Statistical analysis was not employed for a variety of reasons - primarily a lack of statistical power and an evident lack of control of extraneous variables in participant selection.

Overall Data

Two empirical overall measures were taken. Firstly, the total time taken to reach the end of a game was measured. Note that as it was possible for a given game to be impossible to complete or that a player simply failed, this does not necessarily represent a 'complete' state. In order to measure how complete a game was, a second measure of 'depth' was taken. This was a count of how many cards were face up on the table at the end of the game (including cards moved into finishing piles), and therefore how 'deep' into the game a participant had managed to get. There was a minimum score of 0, and a maximum score of 41. This was because there were no kings in use (making the maximum number of cards 48) and seven cards were face up on the table at the start of the game. A third measure of 'time per depth' (TPD) was generated by dividing the time by the depth obtained to

give an indication of how quickly participants were making progress through the game whilst controlling for differing play lengths.

	FreeCell			Wild 7		
	Time (seconds)	Depth	Time Per Depth	Time (seconds)	Depth	Time Per Depth
Baseline	228.61	21.93	11.22	387.55	20.53	21.90
Rule Change	257.74	24.27	10.98	467.63	25.13	18.91
Raw Change	29.13	2.33	-0.24	80.08	4.60	-3.00
Percentage Change	12.74	10.64	-2.14	20.66	22.40	-13.67

Table 3.1: Mean values for overall measures, all figures given to 2dp

These figures provide a number of basic observations about the experiment. Post rule change both groups appear to be getting deeper into the game. Their efficiency may also have improved as tpd was different for both groups.

The groups may have started at different levels of baseline skill. The Wild Sevens condition participants took significantly longer and did not get as far into the game as in the FreeCell condition even before the rule change. The difference in depth achieved as a result of the rule change between the two groups appears reasonably consistent considering the small sample size, therefore the two rules appear reasonably equal in terms of the actual benefit they give to players for completing the game.

Confidence and Performance

Prior to the experiment as noted, participants completed a brief Likert scale questionnaire that measured participant confidence in their playing abilities. This concerned both solitaire specifically, and card games and strategy generally, including their perception of their ability to adapt. To examine if there might be a relationship between confidence and task performance, these scores were plotted against the difference between depth scores between conditions.

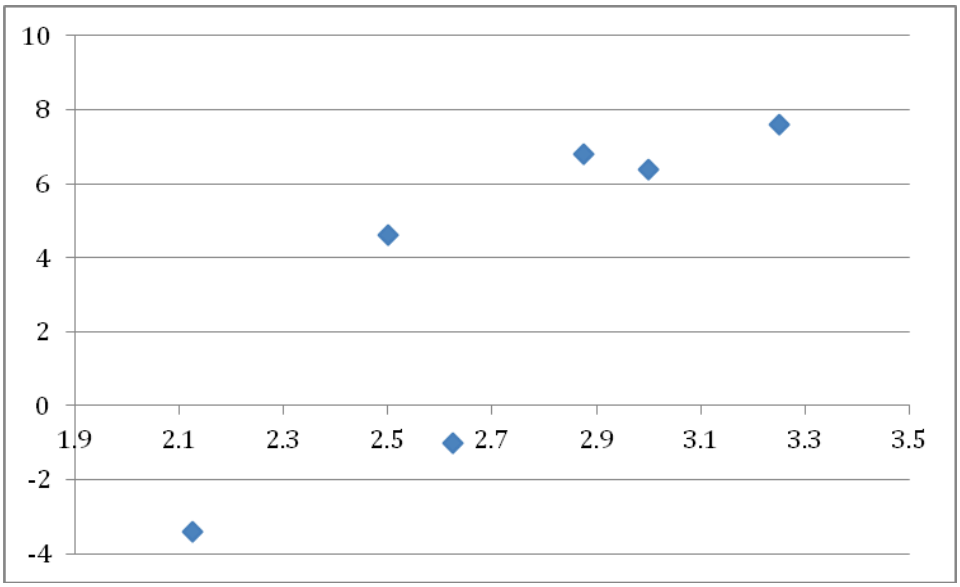


Figure 3.1: Participant confidence (x-axis) against relative change in depth between trials (y-axis)

Figure 3.1 suggests a correlation may exist between the two factors. This may simply represent participants' accurate estimation of their own abilities. However, it was also possible that this was indicative of the manner in which new strategies were tried and adopted; that confidence indicates how successful a participant might be because they were more willing to try things.

Learning and Progression

Also of interest in this study was how participants progressed over the course of the experiment; the development of strategies and skill. The metrics detailed above could also be tracked on a game-by-game basis. Initially, the baseline games were averaged as a whole (since at this point there was no difference between the conditions).

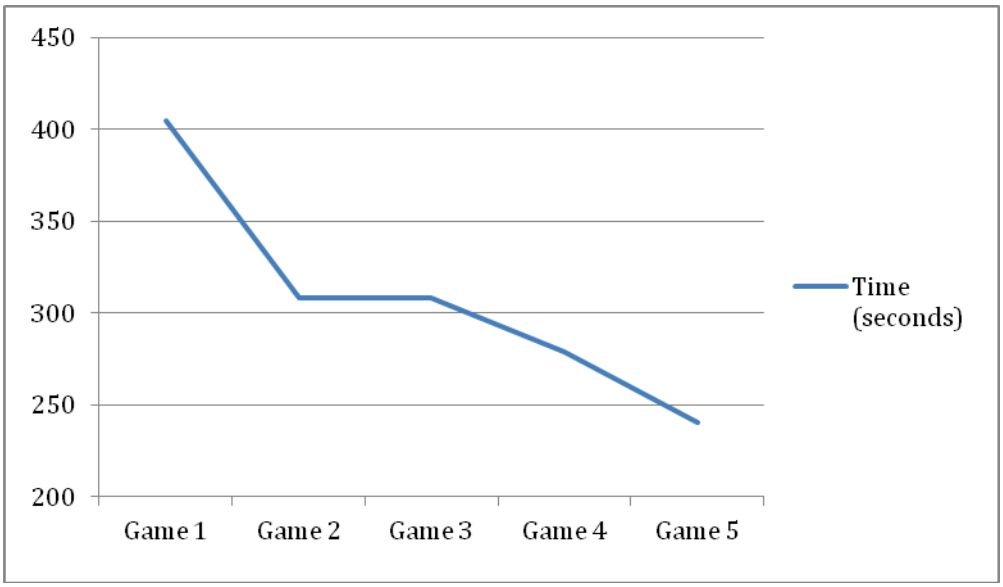


Figure 3.2: Mean time taken to complete baseline games for all participants in seconds by time (y-axis) and game progression (x-axis)

In the above (figure 3.2) there appears to be a learning effect, completing the task with increasing speed in later games. However a similar pattern cannot be seen for game depth (see figure 3.3 below)

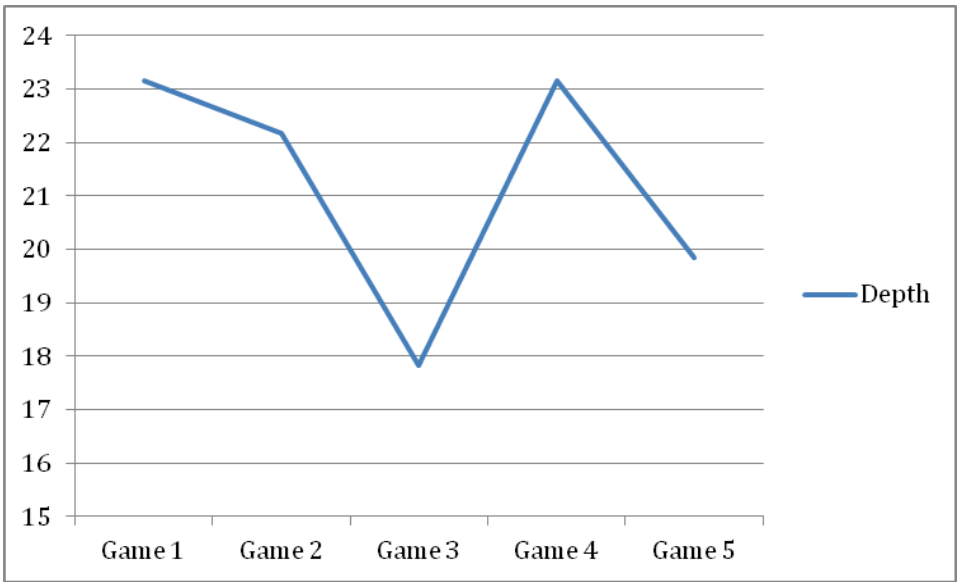


Figure 3.3: Mean depth scores for all participants in baseline games by game depth (y-axis) and game progression (x-axis)

Here it can be seen that the depth obtained does not seem to increase with increasing games, as might be expected. It seems likely that the high variability of

potential setups and outcomes in the task is the reason for this, but no conclusions can be drawn from the data.

Progression within the rule-change trials was also charted and compared between the two conditions. For timing data, there was a distinct difference between the two, as can be seen below (in figure 3.4).

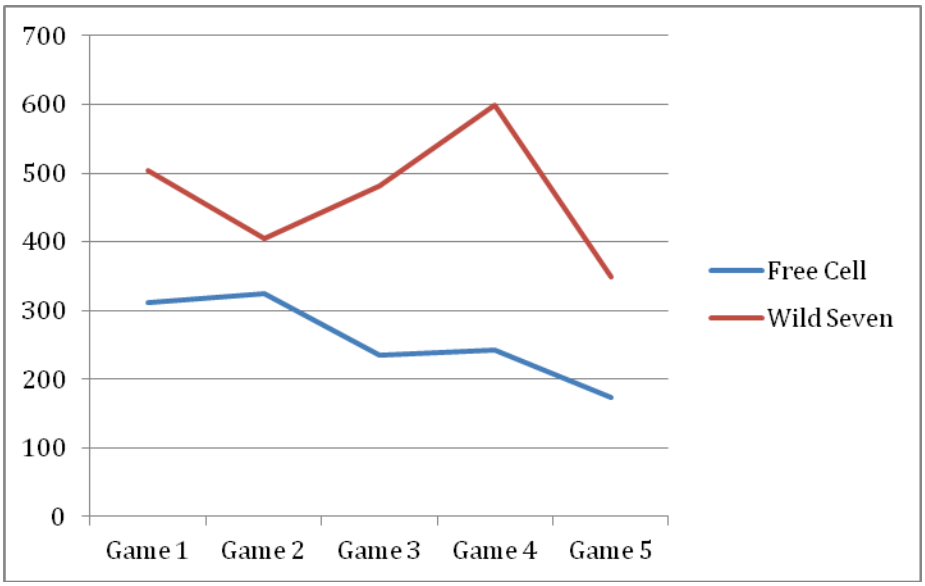


Figure 3.4: Mean time taken to complete a modified rule game in seconds for FreeCell and Wild Seven conditions, by time (y-axis) and game progression (x-axis)

As can be seen above, the FreeCell condition demonstrates a relatively linear progression downwards that is consistent with the pattern seen in the baseline condition. In the Wild Sevens condition, however, there is an upwards trend of time taken that continues for both games 3 and 4, suggesting that it is not a simple aberration (and the participant data confirms that this is not down to a single instance of a person taking a very long time and skewing the average).

This could be for several reasons, the most obvious being that there is some sort of learning process going on for the Wild Seven participants in those later games that is not occurring in the FreeCell condition. This is causing the participants to take longer and presumably as a result gain greater game depth.

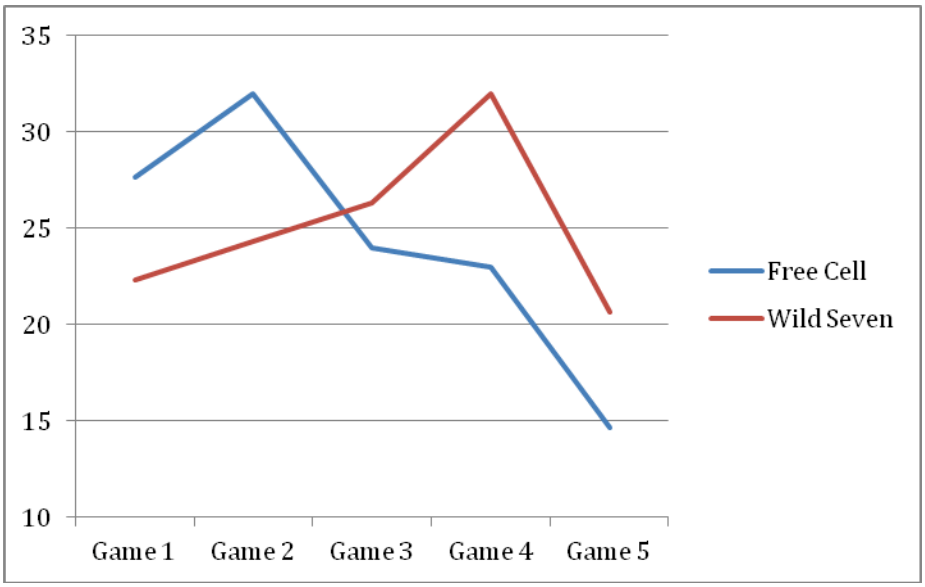


Figure 3.5: Mean depth scores for FreeCell and Wild Seven conditions by depth score (y-axis) and game progression (x-axis)

Here (in figure 3.5) two things are of particular note. Firstly, the hypothesis about the increased time being a sign of increased progression appears to be accurate in the Wild Seven condition, providing a basis for looking for some sort of pattern of new behaviour in that time. Secondly, the FreeCell condition scores actually decline over time – a surprising result given that they also had a new rule to use and goes against expectations of increasing ability. However, it should be noted that all of the games other than the last one are still beating the pre-rule average depth obtained, so there is still general improvement between conditions. The decline can be attributed to two factors in all likelihood: firstly the random nature of the games just being less solvable by chance, and secondly that participants had been playing 10 game of solitaire by the end of the experiment. It is likely that there was a degree of fatigue at this point (several of the participants mentioned such feelings) and the drop in performance for the last game in both conditions is probably indicative of this boredom with the task.

Pattern Analysis

Having established from the above data that there was reason to believe that the two conditions may have been responsible for the differences in performance metrics, the next question was whether the different rules may be generating

different strategic approaches. For this the codings noted earlier were used to examine what moves were made at what time.

Graphical representations of all the games played were generated, and a selection of the graphs and key observations are presented here. Combination graphs were created of multiple games. Since the games lasted a different amount of raw time, these were converted into a percentage and overlaid.

Initial Approaches

The play patterns of the first games with the new rules for both conditions were compared and contrasted. For these graphs, all participant game data was taken and presented on a normalised percentage scale of time.

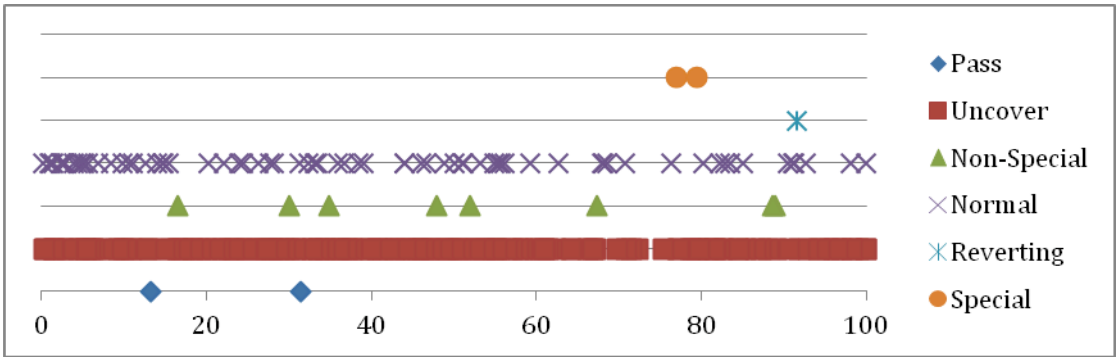


Figure 3.6: Move type (see key) play time by percentage of game time elapsed (x-axis) for the first modified rule game for all participants in Wild Sevens condition.

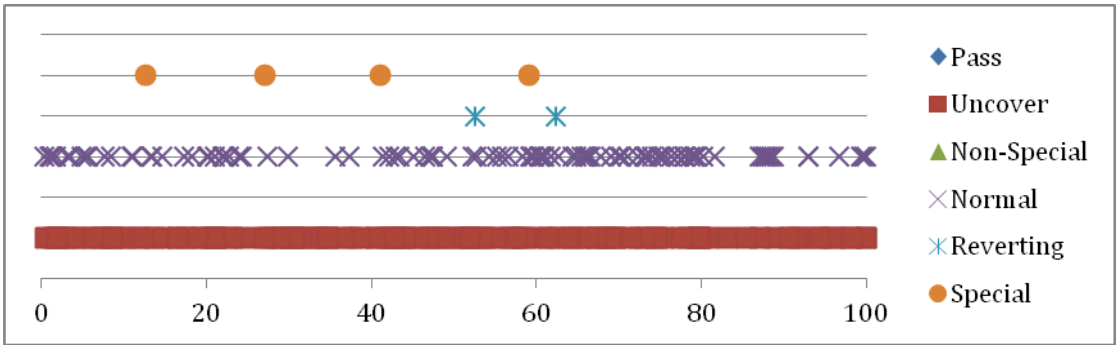


Figure 3.7: Move type (see key) play time by percentage of game time elapsed (x-axis) for the first modified rule game for all participants in FreeCell condition.

As can be seen from the above (figures 3.6-3.7), the most striking difference between the two conditions is the relative time at which participants use the new rule. In the Wild Sevens condition, the rule is only used towards the end of

the game, and only after a significant amount of cycling through the deck. It appears that participants were only using it after all the other available options had exhausted themselves. This may be partially down to availability; in this rule condition there was no guarantee a participant might have access to a seven at any given time, unlike the FreeCell example. However, as the chart shows there in fact *was* availability of sevens, but that they were being used as normal moves instead. It may thus be inferred that participants had the option of making a move, but chose not to.

By contrast, the FreeCell condition is characterised by significantly earlier use of the move. There is some evidence of cycling, as in the Wild Sevens condition, before use, but not to the extent that is found in the Wild Sevens instance. Here instead it appears that participants both have the option of making a move, and are choosing to make use of it.

Given that both rules are functionally very similar, and that they at least provide for the possibility of similar application that participants choose not to utilise, it can be inferred that different strategies may be being applied as a result of the different presentation of the rules. However, an alternative hypothesis would be that the relative complexity of the Wild Sevens instance was deterring participants from its use in comparison to the more straightforward FreeCell.

Final Strategies

As above, the final games for each condition were charted according to move type.

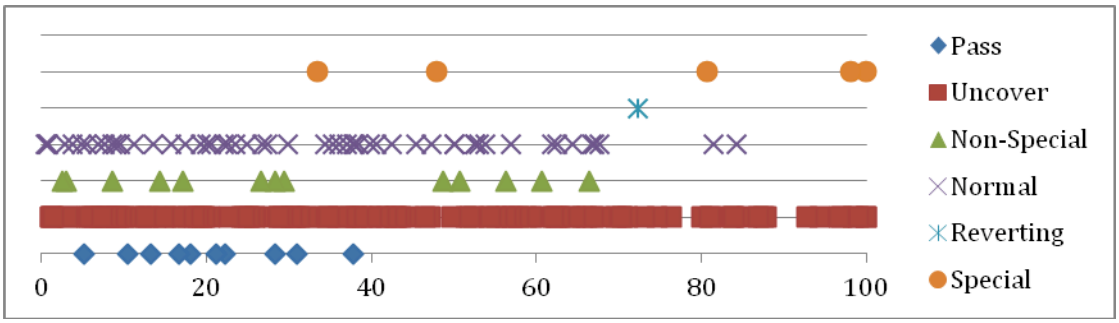


Figure 3.8: Move type (see key) play time by percentage of game time elapsed (x-axis) for the fifth and final modified rule game for all participants in the Wild Sevens condition.

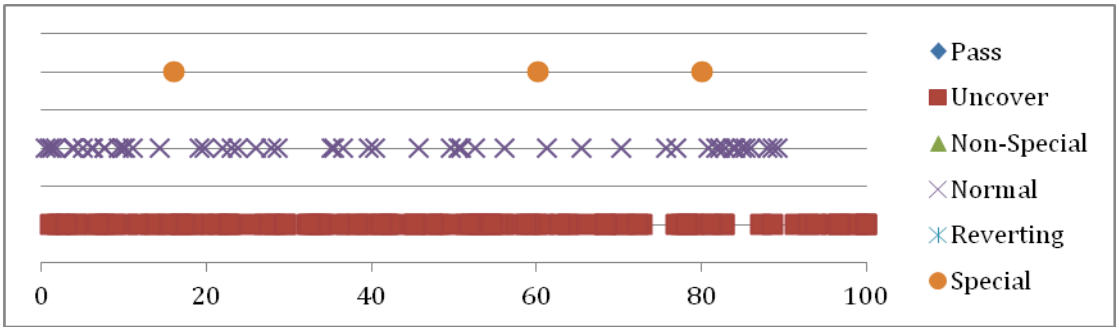


Figure 3.9: Move type (see key) play time by percentage of game time elapsed (x-axis) for the fifth and final modified rule game for all participants in the FreeCell condition.

In these charts (figures 3.8 and 3.9), two things in particular are of note:

Firstly, the patterns of use are now broadly identical. This is not in absolute terms, as the Wild Sevens condition is using the rule more, but in terms of distribution both conditions now use the rule distributed throughout the playtime of the games. Within the individual games, a great deal of cycling through cards can be seen in all conditions before the special rule is applied now. The actual use of the rule appears to be largely equal between the two conditions. This supports the expectation that the conditions were equivalent in the functional change they were inducing.

There is now a much greater amount of passing that can be seen in the Wild Sevens condition. This is significant because it indicates that participants have moved to avoiding using the cards until there is a specific purpose. This is suggests that this condition, like the FreeCell, has moved towards using the rule as a 'get out' clause where no other move is available.

The significance of these final graphs is essentially that two different rules that have been initially applied in different manners have moved towards a consensus application of best strategy.

These observations cannot be taken as empirical evidence for the reasons stated earlier. However, using the observations obtained as a starting point for speculation, two hypotheses for subsequent empirical investigation were generated:

1) Strategy formation is influenced by context, and the manner in which information is presented, independent of the semantic content of that information

2) Feedback will eventually overcome this effect and trend towards a best logical strategy.

A Model of Novel Adaptation

In addition to providing the basis for future hypothesis testing, the above data also provides a basis for some cognitive modeling. As with the above hypothesis generation this is a purely speculative step which will be addressed empirically in subsequent work.

From the above analysis, and additional examination of individual participant game data, a four-stage model of novel adaptation can be proposed. This is a high-level construct, mapping the overall process rather than providing close specificity of task implementation, and for good reason. The nature of adaptation to a novel scenario is, by definition, going to involve utilizing specific processes that cannot be anticipated ahead of time (else the scenario would be anticipated and thus not novel). Thus, an abstract level account of the generalized processes is more appropriate.

Figure 3.10 shows the four proposed stages of adaptation. As can be seen, the model is a circular process, since adaptation and the ability to adapt are properties that seem to be innate, and continuously activated for humans. This model assumes that this is due to a perpetual cycle, rather than individual monitoring systems, as it seems unlikely that the conditions for a single monitoring system being activated could be satisfactorily defined given the range and scope of the real world. The four stages are as follows:

Comprehension: Concerned with what has changed. This covers both the processing of information to be *able* to make that distinction, and also the making of said distinction. If the understanding of a given situation is understood of the current mental model (as previous work generally does) then this stage involves updating said model. It does not involve manipulation of the

information within, beyond the process of becoming aware of the changes that have occurred. Note that this allows for the possibility of errors. These may include, but are not limited to, failure to note a change, noticing a change where there is none and correct recognition but incorrect attribution of effect.

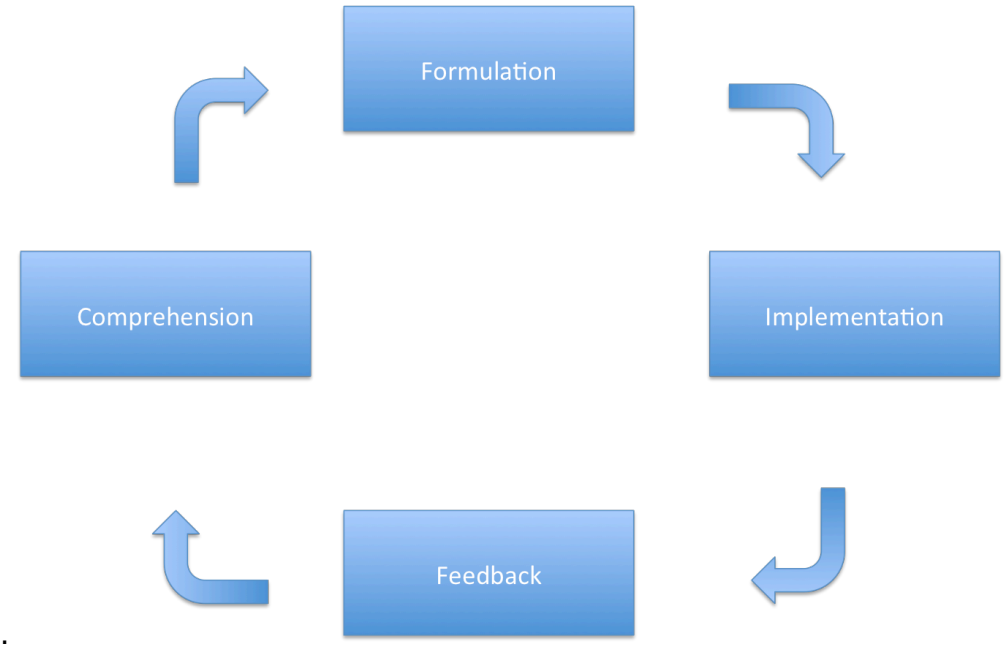


Figure 3.10: A high-level cognitive model of the abstract stages involved in adaptation to a novel scenario.

It encapsulates both the formal changes in rules, but also the implications of these rules. As an example, whilst the rule for the Wild Sevens condition could be verbalized, the exact way in which this impacts game play may not be fully understood, especially since although the rule itself is simple, the interactions it produces are not. The gradual process of comprehension could be seen in the Wild Sevens condition, as participants gradually altered their patterns of use of the sevens as the implications of those rules became more apparent through feedback (see later)

Formulation: Although not directly observable as such, this stage is a theoretical proposition that must exist given our understanding of cognition. Here the altered situation is analysed, considered, and new approaches and strategies are constructed on the basis of the mental model produced in the previous stage.

Implementation: Enacting the plans produced in formulation.

Note that it is possible to change plans, or alter behaviour – but this still indicates another trip through the loop. Implementation intentionally only covers the literal enacting of the plan formed. This could even be to simply take no action. It is also possible that there can be small adjustments to an ongoing plan – again, this would fall under the purview of being produced in formulation.

Feedback: The process of gathering information about the state of the world and specifically the system being considered.

This encompasses both unconscious information being gathered simply as a matter of course (tactile feedback, visual information), as well as any gathering as a result of planned action. Any information that an actor becomes aware of and therefore informs or updates the mental model is considered to be 'feedback', albeit of varying significance.

As should be apparent from this initial description, this is an early framework within which to consider the problem of novel adaptation. There are a number of assumptions underlying it that have yet to be tested either explicitly or as a result of more specific observational studies. As an example, it assumes that processing proceeds in a linear pathway around this loop, where an alternative hypothesis might speculate that feedback loops exist between the individual sections as appropriate. This is considered to be a reasonable proposition, since the stages are largely dependent upon each other for any updating – a mental model will not be updated without new information of some sort (even if that information was a lack of feedback), for instance. Still, this is the reason it exists; to start asking questions of that nature.

Explanations & Predictions

This model can be used to explain some of the results seen in this study.

In the FreeCell condition, participants understood the change almost instantly in terms of how to use the rule, but not the implications or the best-use policies. Therefore, a period of comprehension, where the exact implications of the rule are explored in-situ can be observed – participants 'trying out' the rule right at the start of their first game. Once this has been completed, a better

understanding of the implications is gained and what can subsequently be observed is an iterative process of refinement, via formulation, towards how to apply that understanding.

In the Wild Sevens condition, the comprehension stage was more complicated. Due to the less straightforward nature of the rule several iterations of feedback informing comprehension were required before both the use itself *and* the best use policies were formulated into a similar form to that seen more rapidly in the FreeCell instance. In both cases developing implementation can be observed, and feedback in the form of results is constantly forthcoming. The differing levels of formulation that can be inferred can therefore be presumably attributed to differing levels of comprehension.

Discussion

This study sought to provide qualitative inspiration to base subsequent empirical work on. It has not provided specific validation, but the unverified observations can provide a basis for further work.

The approach appears to have potential. By limiting down the problem space to a solitaire card game, varying strategies resulting from different presentations of equivalent rules may have occured. Although a simplification of the generalized principle being studied, it seems that the approach is providing viable results for further analysis. Therefore the principle of a limited but potentially dynamic environment will be carried forwards for subsequent studies.

The study also suggests that context appears to be able to drive different strategic approaches to essentially the same problem. This has provided the basis for asking new questions at the strategic level, and also for defining the boundaries of the next experiments to be able to address these questions.

CHAPTER FOUR – Framing Task Instructions: The Card Game Study

Introduction

Having identified the impact of framing effects on strategic behaviour in tasks as an area for potential investigation, this chapter will detail a first study in addressing this experimentally.

A task was designed where strategic information was framed. This relied upon the expanded and revised definition of framing as detailed in the literature review chapter. The task was intended to be familiar and thus not utterly novel, in order to limit learning effects as much as possible to being attributable to the framing effects employed. A card game was used for this purpose, based roughly on the rules of 'Uno' although modified as detailed below. The intent was to present the instructions of the task in two different ways, and simply by framing the same information in different ways to cause different strategies to be employed.

Design

For the purposes of this task, a scenario was required that would be restricted enough to enable accurate manipulation of the framing effect, whilst also being open enough to enable viable alternative strategies to exist. Experience with the previous experiment suggested that card games provided a neatly limited environment in which to construct such a scenario, but that pattern-spotting solitaire games did not provide sufficient strategic range to address this question. Consequently a multiplayer card-game was chosen as the basis for the design, where a majority of the actions and decisions could be measured, understood and explicitly quantified, while still enabling a range of options and tactical choices to be observable. The use of a multiplayer game raises questions of experimental validity but these were not considered sufficient to question the results (see the caveats section later for details).

In this section, the rules of the game used will be explained first, and then the manner in which the game instructions were framed will be detailed. After these general hypotheses for the task will be described, and then the specific experimental procedure will be explained.

Game Rules

The game used took the basic structure and form of the games 'Crazy 8's' and 'Uno', with some modification. These were selected both for the relatively simple nature of the games concerned, but also their familiarity – they employ basic mechanics common to many card games. It was chosen to frame the instructions given to participants as the independent variable, anticipating that this would cause strategic differences between conditions.

The rules of the game were as follows:

Objective:

The game was played over a total of four rounds. The objective was to be the lowest scoring participant at the end of these rounds.

Each round could end in one of two ways:

1) One player managed to get rid of all their cards
2) The deck was exhausted, and there were no more cards to pick up.

At the end of a round, points were allocated according to how many cards each player had in their hand, and what type of cards these were. All power cards counted for ten points, whilst all other cards counted for one point only.

Play:

Each player was dealt 6 cards. Play proceeded in a clockwise direction. One card was taken from the draw pile and placed face-up in the center of the table, which was treated exactly as though it had been played, including any effects. Each player then took it in turn to place a card on the pile in the center of the table. The card had to be either the same suit, or the same number as the card face-up in the center. Only one card could be played at a time, regardless of type.

If a player could not play, or choose to not play, they had to discard a card instead face down onto the discard pile. They then picked up two cards. There was an exception to this rule for when a player had only one card left, in which case they just drew a single card.

Power Cards:
Some cards had additional effects when played. These were referred to as 'power cards'.

Twos: The next player had to pick up two cards, and then miss their turn.

Jacks: The next player had to pick up four cards, and then miss their turn

Aces: Could be played onto anything, at any time regardless of suit or number of the card on the stack. The player then nominated a suit for the next player to play to.

Eights: Skipped the next player's turn

Sevens: Reversed the direction of play.

Frame Construction

In order that the game instructions could be framing, there needed to be viable alternative approaches to the game to select between. Scoring cards at the end of each round provided these options.

With no scoring system it is unambiguously beneficial to be holding power cards compared to normal cards, as they enable the player to have more of an effect on the progress of the game. The scoring system caused possessing them to be of ambiguous benefit. They could allow more behaviour, but would potentially penalise a player at the end of a round. Having the deck running out of cards as an end-condition added an additional pressure on this dimension, as there was a finite amount of time in which to get rid of cards.

Another addition was made to the rules in the form of discarding. Because players were expected to wish to get rid of their power cards by any means

necessary, it was permitted for players to discard a card at any time rather than taking their turn. However, as a penalty they would then have to draw two cards. The risk of drawing an additional power card should not be as great as the potential benefit of getting rid of one you are already holding if the game looks likely to end soon. Players were also obliged to discard if they *could not* play, and again had to draw two cards. This forced players to make choices about which cards they valued which could be quantitatively measured.

A novel rule about discarding was also added to enable different behaviour. Because getting rid of power cards was expected to be the preferred strategy for one side of the frame, it was permitted for players to discard a card at any time rather than taking their turn, at the penalty of picking up two cards. Players were also obliged to discard if they *could not* play, and again had to draw two cards. This mechanism was expected to show card preference between the two types (power/normal).

Framing was conducted along the expanded lines detailed in the previous chapter. It was both multi-dimensional (comprising several changes in the rule text) and less tightly bound as classical studies would require.

The experiment was divided into two conditions, high value and low value. All participants were presented with instructions that explained the game and rules at the start of the experiment. The instructions emphasised different strategies for winning via a series of framing manipulations. The high value instructions emphasised that power cards were useful in facilitating a win, implying that they could be more useful if held onto rather than quickly played. The low value instructions emphasised the penalty that players faced if they held onto power cards, and the idea that it was more important to gain an overall low score than it was to win individual rounds. Semantic differences were kept to a minimum. Some uneven repetition was used for emphasis, but there was no information in one condition that did not exist in the other.

High Value Instructions:

> *Today you will be playing a simple card game with three other participants.*

The game will be played over a total of four rounds. The objective is to be the lowest scoring participant at the end of these rounds.

In each round, the objective is to score as low as possible. The round can end in one of two ways:

1) *One player manages to get rid of all their cards*
2) *The deck is exhausted, and there are no more cards to pick up.*

At the end of a round, points are allocated according to how many cards each player has in their hand, and what type of cards they are.

All cards count for one point, except for power cards, which count for ten.

The best score possible is 0, if a player manages to get rid of their cards in all four rounds.

Play:

Each player is dealt 6 cards.

Play proceeds in a clockwise direction. One card is taken from the draw pile and placed face-up in the center of the table, which is played exactly as though it had been played, including any effects. Each player takes it in turn to place a card on the pile in the center of the table. The card must be either the same suit, or the same number as the card face-up in the center.

Only one card can be played at a time, regardless of type.

If a player cannot play, or chooses to not play they are forced to discard a card instead, face down onto a discard pile in front of them. They must then pick up two cards.

The Exception to this rule is when a player has only one card left and cannot play, in which case they just draw a card. Final cards therefore cannot be exchanged.

When a player has one card left, they must say out loud 'last card'. Failure to do this means that they must pick up from the deck.

Power Cards:

Power cards are cards that carry a special rule. (They do however incur a penalty at the end of the game if they are held at the end of the game). Importantly, these can be used to frustrate other players or help a players own game. They can skip other players turns, give them extra turns, or enable the player to play on any card they choose.

Twos: *The next player must pick up two cards before taking their go.*

Jacks: *The next player must pick up four cards before taking their go.*

Aces: *can be played onto anything, at any time. The player then nominates a suit for the next player to play to.*

Eights: *Skip the next players turn*

Sevens: *Reverse the direction of play.*

Low Value Instructions:

Today you will be playing a simple card game with three other participants.

The game will be played over a total of four rounds. The objective is to be the lowest scoring participant at the end of these rounds.

Each round can end in one of two ways:

1) *The deck is exhausted, and there are no more cards to pick up.*
2) *One player manages to get rid of all their cards*

At the end of a round, points are allocated according to how many cards each player has in their hand, and what type of cards they are.

All power cards count for ***ten*** *points.*

All other cards count one point only.

The score at the end of the game will be the sum of the totals from the end of all rounds.

Play:

Each player is dealt 6 cards.

Play proceeds in a clockwise direction. One card is taken from the draw pile and placed face-up in the center of the table, which is played exactly as though it had just been played, including any effects. Each player takes it in turn to place a card on the pile in the center of the table. The card must be either the same suit, or the same number as the card face-up in the center.

Only one card can be played at a time, regardless of type.

Discarding:

There are two conditions under which a player may discard cards:

1) *A player cannot play*
2) *A player can play, but chooses to discard instead*

*In **both** cases a player discards a card onto a pile in front of them, and then draws two cards from the deck.*

The Exception to this rule is when a player has only one card left and cannot play, in which case they simply draw a card. Final cards therefore cannot be exchanged.

When a player has one card left, they must say out loud 'last card'. Failure to do this means that they must pick up from the deck.

Power Cards:

*Power cards are cards with additional rules. **They also incur a greater penalty than normal cards if a player is holding them when the round ends.** Power cards of all types count for **ten** points when a game ends, compared to only one for a normal card.*

***Twos:** The next player must pick up two cards before taking their go.*

***Jacks:** The next player must pick up four cards before taking their go.*

***Aces**: can be played onto anything, at any time. The player then nominates a suit for the next player to play to.*

***Eights:** Skip the next players turn*

***Sevens:** Reverse the direction of play.*

The differences between the two versions of the instructions are as follows:

1) In the third paragraph, the high value condition includes an additional sentence about trying to score as low as possible in each round.
2) The order of the end conditions is reversed when listed. Low Value participants were told the game ended if the deck was exhausted first (implying it was dangerous to hold onto power cards) whilst high value participants were told the game ended when one player got rid of all their cards first (implying the way to win was to try to get rid of all your cards)
3) The description of how cards were scored was broken up into two lines for the low-value participants, and the ten point value of power cards highlighted in bold.

4) High value participants were told that the lowest possible score was 0, by winning all four rounds. Low value participants were reminded that the game would be scored on the sum total from all four rounds.
5) The explanation for discarding is broken into list form for the low-value participants.
6) Power card preamble: In the low value condition the penalty that power cards incur is highlighted in bold text, a comparison to the cost of normal cards is made, and it is reiterated that power cards coast ten points. In the high value condition it is stated that power cards can be used to frustrate an opponent.

Hypotheses

Participants were expected to show a difference in game performance between conditions, as measured by their overall scores (card points) at the end of their game. It was predicted that the high value framing condition participants would hold onto their cards more, and thus score higher.

It was also hypothesized that evidence that participants were utilizing different strategies would be seen in a range of additional measures related to card use and contextual choices. It was anticipated that participants in different conditions would take different amounts of time to make a playing decision and will make choices in different proportions as a result of the framing. High value condition participants are expect to take longer to make a decision and to choose to play more normal cards than power cards when a choice is available.

Finally it was hypothesized that evidence would be seen that differences in strategies reduced over time, as feedback changed the strategic approach based on evidence.

Experimental Procedure

In order to make the games – and thus the decisions of the participants – as similar and directly comparable as possible, pre-sorted decks were used for each

of the four rounds of each game. In this way, the starting hands of all players were identical for each round, the same player started each round, and the order in which the cards were sequenced in the deck was also identical – although once players started making choices about which cards to play this inevitably was no longer completely identical between conditions. It did, however, ensure that cards generally made their way into the game at approximately the same time between groups and conditions.

A random card order was generated for each round of the game through shuffling and that order was maintained for all conditions and groups, with some additional manipulations. Firstly, decks were sorted so that each participant had three (randomised) power cards and three normal cards in their hand when starting each round. Secondly, the decks were arranged so that the last 6 cards in each deck were normal, rather than power cards. This was done to ensure that all players had at least three power cards that needed playing, that every player started from a similar position which was identical in scoring value, and so that as many power cards as possible entered play (cards at the end of the deck were less likely to be played than those at the start, since a player could win by getting rid of all their cards and ending the round). Players were informed that the decks had been randomised initially, but were now identical between conditions.

The experiment was counterbalanced so that there were two males and two females in each group in order to account for potential gender differences, and for potentially different group dynamics between unisex and mixed groups. Participants were seated to play boy-girl alternately. For both conditions it was alternated between experimental instances whether a boy or girl began the first game, although the cards the players received for their initial hand remained consistent with their position.

Before reading any of the instructions or being told the nature of the task they were undertaking, participants filled in a brief questionnaire consisting of both generalised written answers to gauge their prior experience and opinions and a likert scale measure of competitiveness, logical thinking and games playing experience (see appendix three). Participants were filmed with two video

cameras whilst playing the game. Upon picking up or discarding they were instructed to show their cards to the camera, and were prompted to do so by the experimenter if they forgot. Players were incentivised by the prize of a bar of chocolate for the winner, although the general attitude of players and their questionnaire responses indicated that they were generally sufficiently motivated by the game for its own sake. Scores at the end of each round were kept secret, as were discarded cards, so no participants were aware of how well other players were doing compared to them until the final scores were revealed, which maintained motivation.

Caveats

This experiment was a multi-player game, which introduced potential confounding factors. This decision was made for a number of reasons and the results are still believed to be valid. Subsequent experiments remove the multiplayer factor to in part provide validation for the theories produced in this chapter.

A more conventional experimental setup would be to simulate such a decision process in a single person paradigm. From the prior experiment however, there was concern that a limited environment was not challenging or dynamic enough to require strategising from participants. The presence of competitors addressed this concern. It also had the benefit of lending ecological validity to the process, whereas rigorously controlled experimental paradigms can be potentially artificial and unrepresentative. It should be possible to simulate an appropriate environment on a computer, but the required technical skills were not available.

In a pilot study participants were instructed to remain silent, but the unreality of that enforced situation was observed to distract them. In the main experiment players were simply told to play the game as they would socially, and groups enforced a competitive silence by choice. Occasional comments were restricted to competitive banter that did not appear to affect behaviour, but were seen as beneficial for the realism of the situation.

No indicators that the environment was biasing were observed. Because participants held their hand and discard choices secret, it was not possible to

observe other strategies since the necessary context to understand moves in that way was missing. Players were asked about this in the post-experiment questionnaire and indicated that they had not mimicked other players' choices. Results support the idea that framing was a defining difference between groups and it is therefore believed that the paradigm was suitable for the task, although as noted these results will be subsequently addressed in a more rigorously controlled paradigm for validation.

Collection and Analysis

Results were collected and analysed from three main sources. Firstly overall measures about the game were collected as it was ongoing in order to look for general trends. This consisted of the round scores and cards (and card types) discarded for each participant.

Secondly, Results from the questionnaire were examined, and the Likert scale questions sorted and totalled. Qualitative answers were also examined for comments that supported/contradicted the quantitative findings once the analysis was complete.

Thirdly, video data was examined in order to provide information about card choices and timing data. For all moves that were made in all games the following information was recorded:

- The condition, round, and group.
- The cards that each player was holding when the move was performed, the number of Normal and Power cards that comprised that hand, and the game score these were equivalent to.
- The player making the move, their position and sex.
- The card face up on the stack that was being played upon.
- The move being made (play, discard or take).
- The cards involved in that move, and the type of card (Power or Normal)

- The context of that move, consisting of whether those decisions were the only option or if there was an alternative. Discarding and Aces were coded in a similar manner, but treated as special cases as explained later.
- The time at which this move occurred, and therefore the time taken to make the move. Moves were determined to have finished at the point at which the card being played was placed on the pile, or the cards being picked up made it into the player's hand.
- The move percentage: which number move in a game it was, relative to the total number of moves in that game.

Timings were made accurate to the nearest second using the in-built timer in the video recording. This was considered an appropriate level of accuracy due to the inherent noise in inferring cognitive differences from physical action, and the uncertainty in using them to infer said processes.

Questionnaire Scales

The data from the questionnaire was sorted according to scores for Logical thinking, game playing and competitiveness. These scores were used to test between groups to see if the factors were more predicative than the alternative conditions as the analysis below was undertaken. No evidence of this was found. Additionally demographic information was used to similarly test between male and female participants, but no significant differences were observed. The lack of observable effect provide confidence that any effects observed are due to the framing effects rather than a greater degree of competitiveness or skill.

Participants

There were a total of 32 participants, evenly split between male and female. They participated in a total of 8 groups of 4 participants each, with 4 groups in each of the two conditions. The mean age was 23.0, and the Median 20.5.

Results

Overall Score

The overall game scores for each participant were noted and charted as can be seen in figure 5.1. A two tailed t-test was performed on this data and found to be

non-significant. However, this result did not seem congruent with the observable variance and spread. The data was therefore then cleaned for outliers using the forth spread method, and the two highest results were consequently removed from the high value condition. Another independent samples t-test was performed (equal variance was not assumed), this time demonstrating a significant difference, t(25.258) = -2.120, p = 0.044, with Low Value participants scoring significantly higher (and therefore performing worse in the game) than High Value participants.

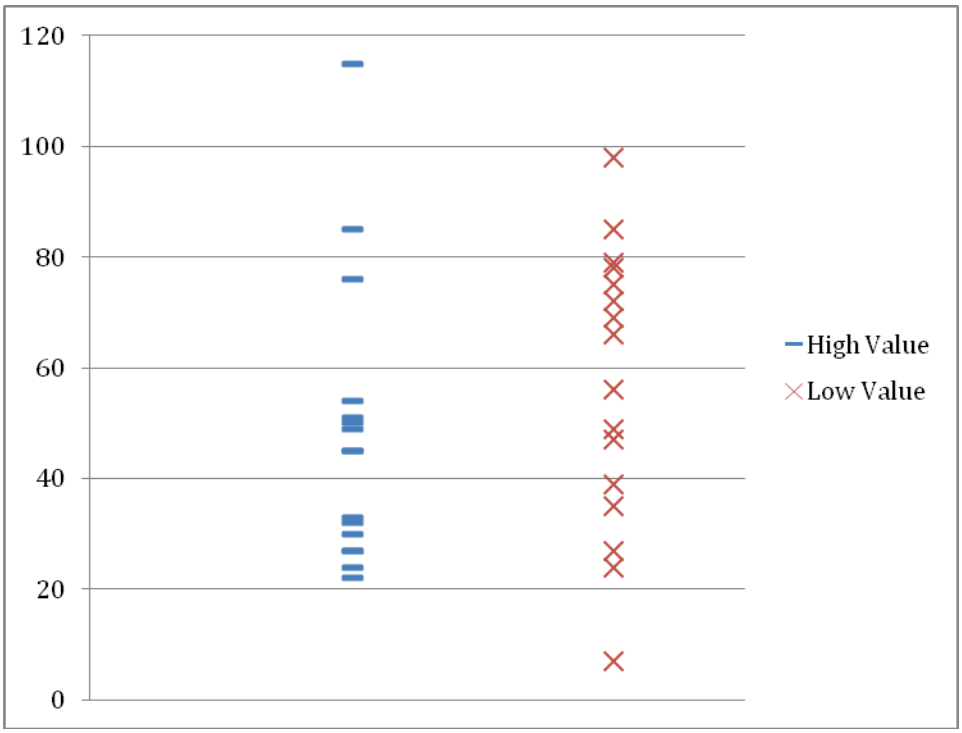


Figure 4.1: Final Participant Scores (y-axis) by Condition (High Value / Low Value). Uncleaned data.

Cleaning the data appears justified by the results obtained. The difference observed suggests that there may be a systematic difference in the approaches taken between the groups.

Playing Times

Time taken to play different card types (Power / Normal) in different conditions (High Value / Low Value) was analysed. The data was skewed, as is common with timing data and it was normalised by taking the log value.

A 2x2 ANOVA with Condition (High Value, Low Value) and card type (Normal, Power) as between-subjects factors revealed main effects of condition, $F(1, 869) = 13.171$, $p = .000$ and card type $F(1, 869) = 5.532$, $p = .019$. An interaction was not found.

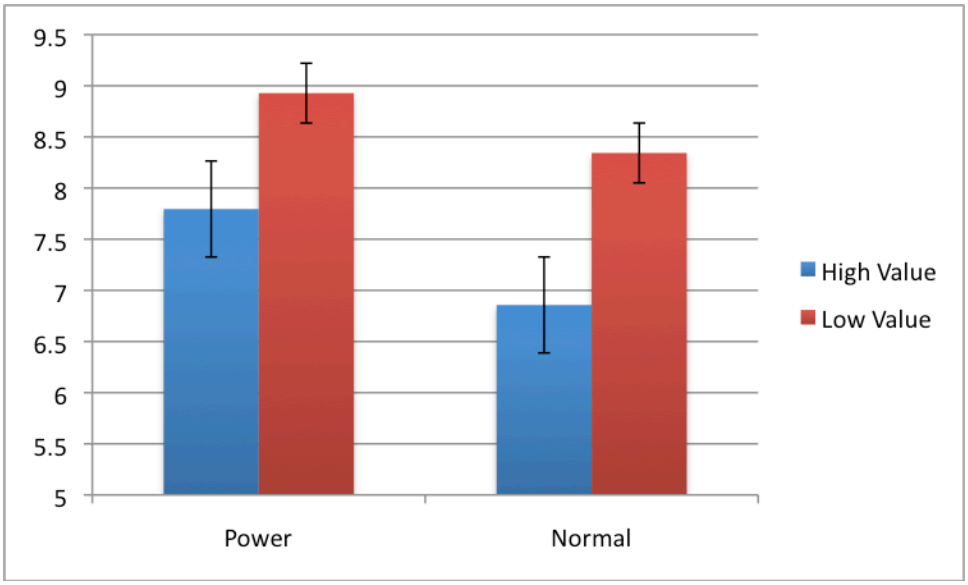


Figure 4.2: Mean time taken for participants to play a card in seconds (y-axis) by Card Type (x-axis) and Condition (High Value/Low Value). Standard error shown as error bars.

This result was then checked by performing a series of Mann-Whitney U tests on the individual elements. Significant differences were found when comparing Power cards between conditions ($U(493)=26865$, $p=0.026$, $Z=-2.228$), comparing normal cards between conditions ($U(379)=15474$, $p=0.031$, $Z=-2.155$), and between power cards and normal cards in the high value condition ($U(454)=22458.5$, $p=0.023$, $Z=-2.278$). No difference was found between power and normal cards in the low value condition on its own ($U(418)=18771.5$, $p=0.060$, $Z=-1.879$) although it was close to significance.

Contextual Data

The decision of which card to play goes beyond simply which type of card is available, but also includes whether alternatives are available, and what those are. Having an alternative available should show a difference in strategic choice. Card use was coded for each move. Moves were described in terms of whether

the other type of card (Normal/Power) was available to play. They were either the 'only available', which mean that there was no card of the alternative type available to play, or 'alternative available' where there was the alternative type of card available to play, but was not chosen. This was also done for discarding moves in the same way. Aces, however, were coded separately and treated as a separate type of power card for reasons that will be discussed later; they are not included in this analysis.

Card choice was compared between conditions. For all instances where there was a decision to be made between playing a normal card or a power card the proportions of this choice were compared between conditions. It was found that high value participants chose to play normal cards in this situation more (21%) than low value condition participants did (12%). A A chi square result revealed that this was statistically significant, $c^2(1, N = 303) = 4.506$, $p = 0.034$.

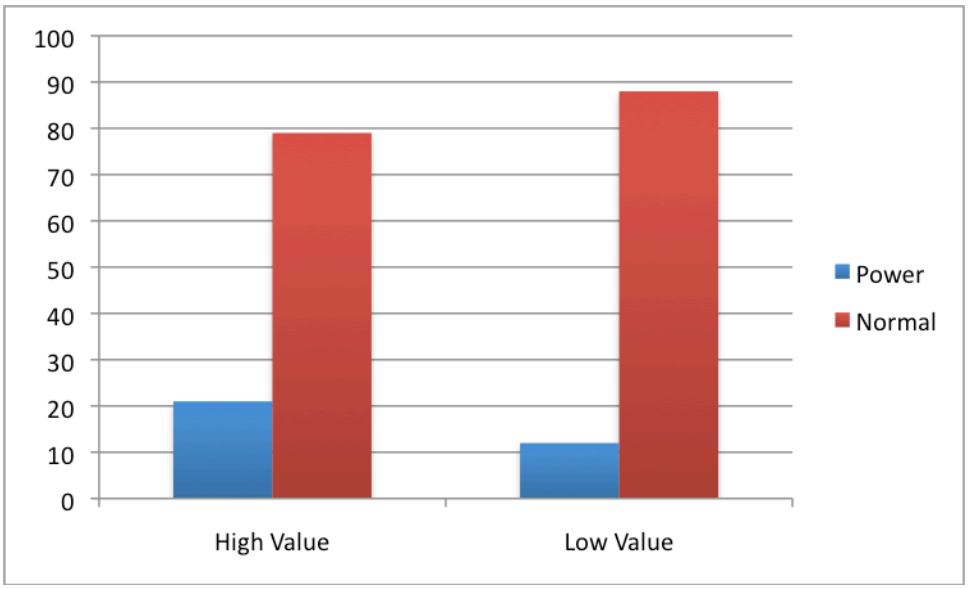


Figure 4.3: Percentage of moves (x-axis) where a card type is chosen over the other (Power/Normal) by condition (High Value / Low Value)

The data was also tested within individual rounds (see figure). There were no differences between conditions within rounds. There were differences between the proportions in the first and last rounds overall ($c^2(1, N = 143) = 10.93$, $p = 0.01$)), in the high value condition ($c^2(1, N = 72) = 4.055$, $p = 0.044$)) and also in

the low value condition ($c^2(1, N = 71) = 5.588, p = 0.018$)). All of this movement was towards playing power cards in preference to normal cards.

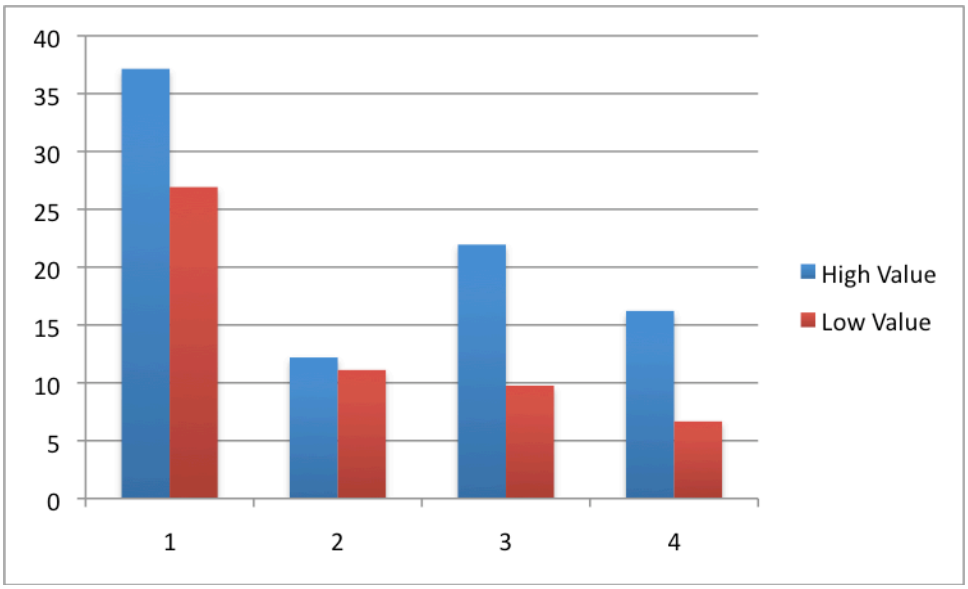


Figure 4.4: Percentage of moves (y-axis) where a normal card is chosen over a power card by round (x-axis) and condition (High Value / Low Value)

Additionally, the time taken to make a choice were compared between conditions using a series of Mann Whitney U tests, but no significant differences were found. This is not in line with the overall data findings detailed above, but can be largely explained by a loss of power. This data set was significantly smaller than the overall data, and it is not surprising that this would result in insufficient power to detect what may have been a real, but relatively small, effect. An ANOVA and series of Mann-Whitney U tests were also performed on the move percentage data to see if these decisions were made at different points in the games (this technique is explained in detail later) but again no significant differences were found.

Overall, context data supports the idea that there are different choices occurring as a result of the framing.

Ace Data

Aces were not counted as a power card, either as an alternative to a normal card, or counted when played as being a power card in the previous section due to their unique properties. Where all other cards could only be played if their face

or suit value matched that of the card on the top of the stack, aces could be played on any card, regardless of face or number value. This enabled a greater degree of choice, and the existence of viable alternative strategies. High value participants would be predicted to hold on to aces when given a chance to play them, and low value participants would be expected to play aces where they were not needed.

Ace playing was coded contextually. Because aces could always be played once in a player's hand, the relevant context was whether they were the *only* option available at that point or if a different card was available to be played. This would illustrate if participants were holding on to, or getting rid of aces.

The numbers of each type of these moves were collected for both conditions, and a chi square test was performed on the data. The test revealed there was a statistically significant difference in the move proportions between conditions, $c^2(1, N = 60) = 5.610$, $p = 0.018$. In the high condition aces were played when an alternative was available only 33% of the time. In the low condition this was 55% of the time.

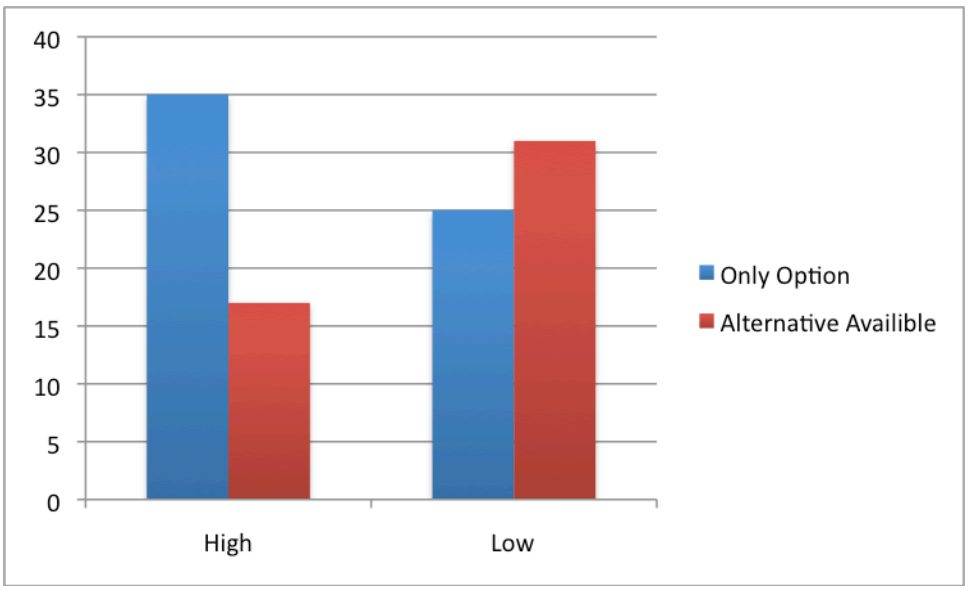


Figure 4.5: Number of times (y-axis) an ace is played in a given condition (Only Option / Alternative Avavilible) by Condition (x-Axis, High / Low)

Ace data was also compared by round. No difference was found for the first or third rounds, but were seen in the second ($c^2(1, N = 28) = 4.368$, $p = 0.037$) and

fourth rounds ($c^2(1, N = 24) = 5.714, p = 0.017$), in both cases with High Value participants tending to wait until playing an ace was the only option more. There was also a difference between rounds one and four in the High Value condition ($c^2(1, N = 23) = 4.915, p = 0.027$).

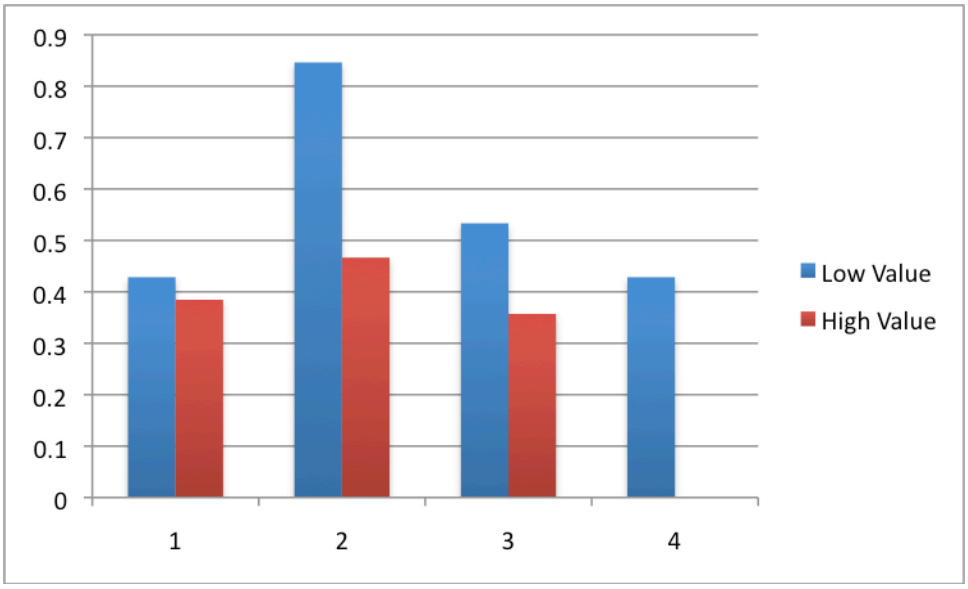


Figure 4.6: Proportion of Aces played (y-axis) when an alternative available by round (x-axis) and Condition (Low, High)

Game Position Data

An additional source of data to be examined for evidence of systematic differences is the point in a game at which an ace is used. If there is a significant difference in when the card is played between conditions, this could be evidence of differing strategies. Raw time data would be potentially skewed and biased by pauses in game play or differing game length. Instead, the move count was used to generate a game-complete percentage which indicated the relative position of a move in the game. Ace move types were categorised in the same way as the previous section (Alternative Available / Only Option) as table 4.1 summarises.

A 2x2 ANOVA with Condition (High Value, Low Value) and move type (Alternative, Only Option) as between-subjects factors revealed a main effect of Move Type, $F(1, 104) = 3.970$, $p = 0.049$ and no other effects. This test, however, failed to meet the expectations of homogeneity and therefore a series of Mann-Whitney U tests were undertaken to compare between the groups directly. A

significant difference was found between move types in the High Value condition U(52) = 184, P = .027, Z = -2.214 but not in the Low Value condition, suggesting a difference in ace use between conditions.

	High Value	Low Value
Alternative Available	70.0	54.60
Only Option	54.50	50.50

Table 4.1: Mean number of game moves completed (percentage) when an Ace is played by condition (High Value, Low Value) and Move Type (Alternative Available, Only Option)

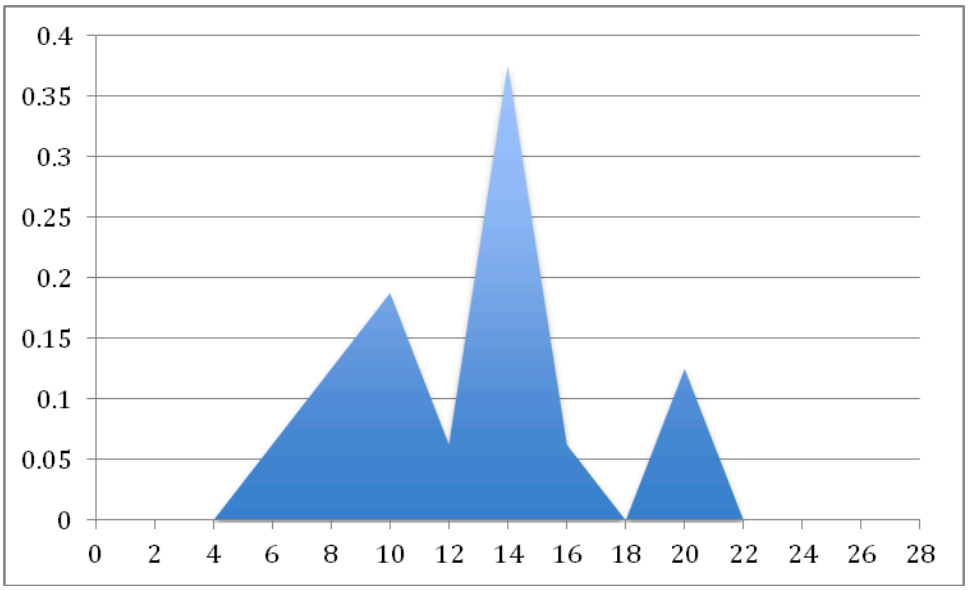


Figure 4.7: Frequency distribution of proportion of total population (y-axis) of time taken to play a card (x-axis) when an alternative is available in the High Value condition.

The individual move time data for this set was then compared. Since the data was non-parametric a series of Mann-Whitney U tests were used to test between the conditions, and a significant difference was found between the time taken to play an Ace when there is an alternative available between the high and low conditions (U(48)=172 p=0.048, Z=-1.976). No significant difference was found for move type within the high value condition, although it was close (U(52)=210,

p=0.087, Z=-1.711). The Alternative Available data was then plotted as frequency distributions.

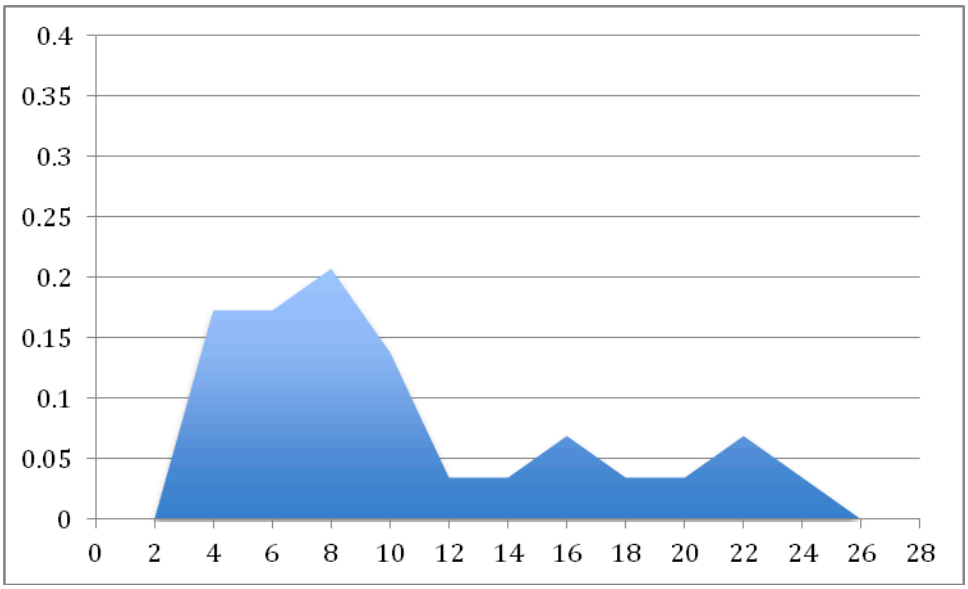


Figure 4.8: Frequency distribution of proportion of total population (y-axis) of time taken to play a card (x-axis) when an alternative is available in the Low Value condition.

Discarding

A final source of data is the cards discarded in the course of the game. Discarding was both a condition of being unable to play, and also was available for players to choose to do in lieu of a move. In theory it provided another way to be able to get rid of power cards.

This data was coded in the same way as the other moves were, with it being noted if cards were discarded wilfully or normally, what type of card they were and also if the card type discarded was the only available, or not. A series of tests were performed, but no significant results were found, either as a measure of the proportions of choices made in each condition for which a chi square was performed, nor for the timing data between conditions and card types for which a series of Mann-Whitney U tests were undertaken. There were no identifiable differences between the conditions.

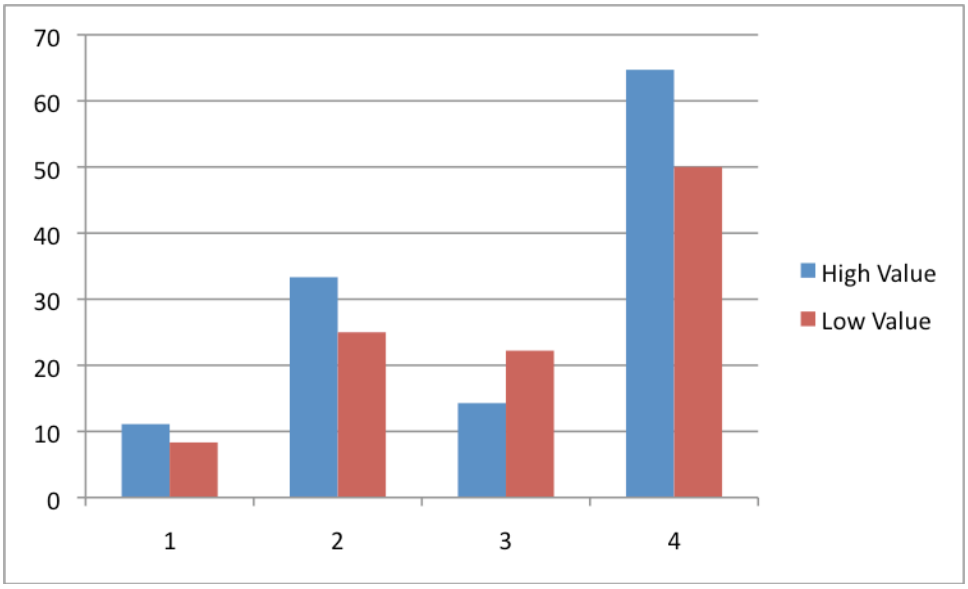


Figure 4.9: Percentage of discarded cards that were power cards (y-axis), by round (x-axis) and condition (High Value, Low Value)

Graphing the data as in Figure 4.9 suggests there may be a potential learning effect. No such effect could be statistically detected, although the data set was too small to consider this conclusive.

Discussion

The hypotheses described at the start of this section will be evaluated, and then additional conclusions that emerged as a result of the evidence gathered detailed. Implications for the model specifically, and then the more general significance will be evaluated, before new hypotheses are suggested for further study.

Hypothesis Testing

The first hypothesis stated that a difference was expected to be observed between conditions as measured at the overall game score level. This was supported with the caveat that the data required cleaning for outliers to detect.

Secondly, it was hypothesised that effects would be seen at additional measures. This was supported, as effects were seen between conditions for card choice (power/normal) time taken to play (power/normal) and within the ace playing data. The differences were also found in the direction that was anticipated, with

high value condition participants choosing to hold onto power cards longer (both overall and for aces specifically) and taking longer to make a decision overall.

Finally it was hypothesised that differences between conditions would reduce over time. This was not supported as differences remained in card playing choices between the first and last round for both normal/power card choices, and also when aces were played. However, in both cases there was evidence that the trend was in the same direction between conditions. This suggests that the underlying idea behind this hypothesis (that feedback would inform an optimal strategy common to both conditions) may have some validity.

Additional Conclusions

Firstly, we can conclude that the difference observed in overall scores is real and significant. The range of systematic differences demonstrated in the move-level analyses provides sufficient evidence to believe participants were acting differently in the different conditions, and the data cleaning removed outliers that were skewing the data and obscuring a real effect. Participants were successfully framed by different instructions, with high value participants, on average scoring better. We can see this in the difference of the overall timing data, the difference in the choice to use normal or power cards and in the use of aces.

Secondly there appears to be an interaction between framing and feedback. Although the card choice results did not reach a shared norm and the conditions remained different, they *did* move in the same direction which suggests that both sets of participants were adjusting their actions in the same direction. It would appear that a frame can be altered by feedback, although there is insufficient evidence to conclude whether it would eventually render a frame irrelevant. Additionally it should be remembered that this result is not necessarily transferable to other tasks. The feedback in this scenario was unambiguous, accurate and complete. In the real world it is entirely possible for feedback to be misleading, ambiguous, inaccurate or incomplete – and it is unclear to what degree this may have an impact on framing.

Having drawn conclusions from some of the specific results, more general conclusions looking at the body of results as a whole will be addressed.

Selective Application of Framing Effects

There is evidence that within a given task the same framing can have different results on different aspects of that task. This implies that on some level the frame is considered and applied according to the context a decision is made in. It can be easy to think of framing effects as setting a largely unconscious tendency which is then consciously applied – a viewpoint largely supported by the fact that participants do not generally acknowledge being framed, even when it is illustrated to them (Gigerenzer, 2000). In this experiment evidence suggests that framing is not necessarily automatic or generic but appropriate and contextual.

In this experiment, measurements of framing effects were taken for three measures; a) between normal and power cards, b) the use of aces and c) discarding. Different types of effect were seen at each despite the fact that each involved elements of the same basic decision: how and when to play power cards. For the choice between normal and power cards the effect was to alter the ratio of the decision made, but it seems not the underlying strategy or rationale behind it as there was no evidence of differences in time taken to play or when the decision was made. For Aces, not only was the choice made differently between conditions, but timing and positioning data showed that this was varying according to the context it was made in. Finally, for discarding no effect could be observed at all. When contrasting between these three different results it is clear to see that the same frame is having a different effect (or non-effect) in three different aspects of the same task.

A possible explanation for why this is occurring can be worked from prior research, which observed that ambiguity appears to have a role in determining when and how a framing effect is applied. There must be a level of uncertainty as to the optimal course of action or correct answer (as can be seen in the Asian flu example cited earlier where the statistical difference between the solutions is nil). In these situations, participants rely on framing information to discriminate

between otherwise largely indistinguishable choices. The suggested difference here is that when ambiguity varies, framing behaves differently.

When choosing between power and normal cards the level of ambiguity and uncertainty is low; power cards are generally best played when the opportunity presents itself, as the objective is ultimately to be rid of all cards, and they carry more penalty than most whilst providing little benefit from holding on to them. There are plausible benefits in *certain* situations, and generally it is a question of whether a player wants to take the risk of holding on to one, but the weight of evidence supports getting rid of them. The framing effect is limited because the amount of ambiguity is limited, and the effect equates to that of applying the same discriminatory heuristic in different parameters, namely holding onto power cards one time in ten, or one time in twenty.

In contrast, when considering the use of Aces there is a great deal of ambiguity. There are competing, plausible considerations: on one hand they represent the same danger as any power card, in that they will significantly increase a participant's score at the end of a round and therefore should be gotten rid of quickly. On the other, they are also able to be played on anything and therefore are especially useful when a player has very few cards and is more likely to face a situation where none of their cards can be played. As a result of greater ambiguity the framing effect is more pronounced in its effect, not only in terms of which choice is made in a decision, but also the strategy on which that decision is based is different. Here in the low condition participants are far more eager to get rid of their Aces; they play far more of them in situations where another card is available, and take a lot less time to think about it when they do. By contrast those in the high value condition not only take more time before making such a move, but they also make those moves later on in the game, at a time where a strategy is actually viable or useful. So in this case participants are applying a different heuristic altogether, depending on condition.

What this explanation does not account for, however, is the discarding data. Here ambiguity is at least sufficient that there is uncertainty about the best tactic to proceed with – more power cards are discarded as a proportion of the total in

later rounds, and the possibility is there to treat cards differently. The expectation was that this would be framed like the other elements of the task. So the question becomes: why not?

In this task, participants were presented with a situation where the basic mechanics (power cards, aces) were largely familiar to them as a result of having played similar games before, something supported by the questionnaire responses. Discarding, however, was not part of this generally familiar paradigm, as evidenced at least in part by the fact it was not easily understood at first – it was common for the experimenter to need to correct or explain the procedure early on, and several errors concerning this element of play were retrospectively noted when the video was examined.

This ties in with the explanation suggested for the differences in framing between the other two levels. As was noted prior, there, framing was occurring to some degree at the strategic level. For discarding however, participants were still starting to understand the process at all. No framing effect occurred because participants did not understand discarding well enough for it to be influenced: they simply did not make the connection.

However, discarding is not so complex an idea that we would expect people unable to grasp the concept as a normal process – indeed, in prior research people have been framing doing unfamiliar tasks. This is where the second point comes in. Because there were decisions and strategies to be implemented within an understood framework and these comprised the majority of the task, this took precedence over analysing a new component. This fits with the pre-existing research theory of limited search: there is a finite amount of processing that can occur before a decision is made. Here participants lacked the free cognitive resources necessary to comprehend discarding sufficiently that it could be framed.

These observations taken together suggest that framing occurs to some degree at a strategic level of thinking, that plans are made and executed at least partially based on the biases that a frame can impart. The differences in framing effect between the levels supports this – a simple blanket rule of ‘try to throw power

cards away' does not explain that variation. If accurate, this provides a reason that it is necessary to move beyond single-decision paradigms for studying framing effects, as they are insufficient to capture the potential complexities of the phenomena they induce.

Finally these observations create a number of implications for existing theory. Firstly they support the idea that ambiguity is key in a framing effect working, and extends that finding to a more task-orientated environment. We can see this both from where the frame was applied, but also in how there was regression towards a shared norm based on quantitative feedback. Secondly by widening the scope within which framing effects and their impact is considered, questions are raised about how and at what point in cognition a frame can have an effect.

Learning Implications

This experiment provides some insight into how learning may progress when a framing effect is present. It should be noted at this point that there are several reasons to interpret the learning data with some caution. Players only engaged in four rounds of the game, a limited number when assessing how the participants improved. The nature of the rounds also provided a limited amount of opportunities for feedback in the form of a round score, and therefore a limited opportunity to assess how well a particular strategy was progressing. Additionally there was variation between rounds – the conditions played the same games in the same order, but those games were different to each other, and some may have lent themselves to certain decisions or scores more than others. The point of these observations is not to say that we cannot draw trends from the information collected, but rather to note that it is likely inappropriate to draw too specific conclusions from the variations. As an example, both the Ace use data and the discarding data have rounds with slightly odd patterns from one or both of the conditions.

However, and with these things borne in mind, there are still two conclusions that can be drawn from the evidence. Firstly, all three measures (discarding, Ace use and power/normal card choice) appeared to show some sort of effect, and

secondly all conditions also appeared to show a trend towards a shared position, rather than diverging.

These are significant because they suggest two things about learning in a farmed task. Firstly it suggests that feedback and evidence can overcome a framing effect. It supports the position that it is ambiguity that allows a framing effect to have an effect – as feedback removes ambiguity, so the strategy alters. Indeed, both conditions suggest change as the rounds go on for all measures, indicating that even when the 'correct' hypothesis and strategy is primed, participants are still refining and perfecting their behaviour as would be expected.

Secondly, this improvement and these tendencies are notable for the fact that they appear to move towards a shared norm. In all measures, both conditions move towards the same point as an optimal solution (whether it *is* an optimal solution is open to debate, but the convergence is still relevant). The task was short enough that the convergence is not conclusively shown to be complete by the time the game ended, so there is definitely a case to be made for framing effects impacting the time taken to reach an optimal solution. However, the overall conclusion is still pertinent: framing effects have not shown the solution to diverge, and the suggestion therefore is that in tasks where there is an optimal state to be reached, framing will not affect the eventual conclusion reached provided there is sufficient feedback.

Model Implications

The observations in this experiment broadly support the model as proposed. The difference in frame implementation between the different activities measured can be explained by the stages. Before the game began and when participants were reading the rules, they comprehended the basics of the game from recognizing similarities to previous such games. The main changes were to the scoring system, which affected the value of the cards, and the framing provided the basis for the differing strategies that were developed as a result. So the pre-game formulation produced framed strategies, and there were different approaches to different cards within these strategies. Feedback from both the round scores and cards being played then informed these strategies by

enhancing comprehension – primarily the importance of getting rid of power cards if it was not initially fully understood.

The discarding that failed to be framed can be explained by the fact that it was not sufficiently comprehended. The errors that came with the discarding system supported this view of incomplete comprehension. It was only with the feedback from playing the game that greater comprehension of the role of discarding in the game could be appreciated, and as a result only then that formulation could produce appropriate strategies for dealing with it.

This re-assessment of the model is showing some potential predictive validity, however it remains more useful retrospectively. Questions that arise from this experiment are in how to predict what may be comprehended and understood to enable formulation – without this knowledge the model will remain more useful as a post-hoc assessor of efforts to adapt rather than predicting success or anticipating potential problems.

Significance

Having discussed the implications of these findings on theory, and the potential future research questions it raises, it is worth also considering what significance these results hold as a whole for theory and everyday life in general.

Possibly the most important conclusion to take away from this experiment is the apparent limits of framing effects. It is easy to read the literature and assume that our every decision and move may be dictated by the manner in which we experience information – an assumption that flies somewhat in the face of everyday experience. It is not that we are unaffected by framing, but that these effects tend to matter at the *start* of a process. Experience and feedback allow us to overcome these cognitive biased. Framing effects are not forever.

Of course whilst we say that, it is important to consider that such a situation actually represents a great deal of the things we encounter and tasks we perform. The experiment detailed describes a situation that was fundamentally familiar, but with some new elements to it – a different set of expectations on the same basic mechanisms. The same description could easily be applied to dining

at a new restaurant, driving a new vehicle or even meeting a new person. And as we can see from the data collected, framing effects can have a distinct impact on how we approach a task. The initial strategy, the first approach – these are commonly non-trivial experiences, especially in situations where there may not be the opportunity to gain true feedback before needing to perform – combat situations for a soldier, for instance. All the training in the world ultimately cannot account for a live fire experience. Additionally, whilst the feedback in this case appeared to correct for the sub-optimal formulation of strategies, this occurred mainly in-between rounds when information about scores became apparent to participants. Combat is a good example of a situation where useful feedback is often of this sort – available once the immediate experience is over and actions can be considered at length, but not necessarily available at the time and in the chaos of the moment.

In these situations, this research raises questions about the nature of instructions that should be given. Specificity, it would seem, is important not just in general terms for what the situation is, but in how that information needs to be applied – the lack of a framing effect for the discarding choice illustrates how having the big picture, even in the correct manner, many not be enough. Smaller elements that *should* be treated in this way may fall by the wayside, and to participants' detriment (discarding was a potentially very effective means of getting rid of power cards). The same sort of consideration is true when dealing with exceptions. In the experiment, Aces were a unique form of power card - but they were still a power card and low-value condition participants applied the framing sub-optimally as a result. As prior research has highlighted, eliminating ambiguity would appear to be key for good decision making. It may be that providing people with general rules – but then making a point of highlighting the importance of considering individual instances – is of greater effectiveness.

Of course, those points make the assumption that ambiguity can be eliminated to some degree, which is not necessarily the case. There may not be the time to do so, or indeed the requisite information available. Additionally, it may be that framing effects can make good use of such ambiguity – if a course of action is preferred, it provides a way to make it the initial approach people adopt without

seeming biased in the instructing. If instructions are biased or perceived to be so, there is always the chance that people will go against them on principle. Indeed, there are many situations where people may not necessarily trust the source providing the information – intelligently framing the instructions could provide a mechanism for influencing the path taken without seeming to lead them.

This experiment also suggests that it may be more important to frame for the critical things where people may go wrong if ambiguity is high. The smaller things where ambiguity is low – in this case basic power cards and normal cards – won't be as affected as a result of that lower ambiguity. The key may lie in identifying potential pitfalls, and framing for them. Indeed, the lack of an effect in discarding demonstrates that there are limited things that will be taken in when prepping for a new task. Making sure that the essential points aren't part of that, and highlighting the unfamiliar, are simple steps that could potentially enhance performance in critical areas.

New Hypotheses

Having addressed the hypotheses and examined the theoretical and practical issues associated with these results, the next natural question is how to further this research.

This experiment offers a number of observations that could provide the basis for future investigation, and it will not be possible to pursue them all. However, it is possible to identify some of the key questions raised to take further.

Firstly, there are general questions about the repeatability of these results in a different paradigm and with different framing mechanisms etc. Whilst there is certainly reason to be confident that the data presented here is valid, these sorts of results and speculation nevertheless demand confirmation that there isn't simply an order effect or situational bias at play that is creating the observed properties. For this experiment and line of research this means primarily that another experiment should seek to examine similar questions utilising a different framing mechanism, and to do so in a different setting to that of card games.

Secondly, there are a number of questions that arise from issues surrounding feedback. This experiment had two notable properties concerning feedback: a significant source of it was only received at the end of each round (in the form of a participant's score for that round) and that it was qualitative and unambiguous – higher was worse, lower was better. Whilst neither of these were inappropriate, it is also easy to consider alternative methods in which feedback might be obtained; it might be qualitative or quantitative, it could be reviewed more directly in line with actions taken, and it could be ambiguous. It is common in real life to see a single set of statistics interpreted differently by different parties according to their priorities and beliefs, so if feedback were ambiguous would the same optimization be seen in a task? Or would it simply be used to confirm the pre-existing biases engendered by the frame?

Thirdly, how framing might persist also creates questions of whether the way in which a frame is presented can affect this. In this task participants were initially framed, but not subsequently whilst undertaking the task. It is not hard to imagine a situation under which framing might be reinforced however – and would the repetition of a frame be sufficient to continue its influence on task decisions? Or would feedback still end up as a more important determinant, and repetition simply weaken the effect of the frame as its lack of actual predicative validity was shown through feedback?

CHAPTER FIVE – Frame Positioning and Confidence in a Descriptive Task: The Festival Study

Introduction

Previous work has established framing effects exhibiting distinct properties in an ongoing task paradigm. The goal of this chapter is to further investigate this by reporting a study of framing effects in a forced choice experiment. The experiment utilizes a progressing thematically linked series of decisions conveying a story about a rock festival.

This study was designed to test the hypotheses generated by the previous experiment, but also move beyond the paradigm thus far employed (card games). It was also designed to more closely reflect classic framing approaches by reapplying the Asian flu statistical weighting and employing a forced choice paradigm. Confidence was also introduced as a measure in order to reflect graduation in decision making not reflected in a pure either/or dichotomy.

Prior research has made use of confidence to study decision making. Participants have been shown to approach tasks differently as a result of varying confidence from prior contemplation (Koehler, 1991), confidence was seen to affect influence in group decision making (Zarnoth & Sniezek, 1996) and confidence can also act as a predictor of task success (Feather, 1968). Here it was measured for these reasons, but also as a factor potentially influenced by framing. It was anticipated that framed confidence may be higher than unframed, as the (perceived) additional information would help to justify choices made.

Design

Overview

A task consisting of a series of 11 binary questions that related to an ongoing task was designed. A narrative was constructed around the participant managing a music festival, during which an outbreak of a virulent, unidentified disease

occurs and steps must be taken to control it. The binary distinction used was one of deciding between using internal or external solutions, with the exact nature of these varying according to question. Additionally, a confidence measure was taken for each question on a 7-point scale. Once a decision was made, feedback was given detailing the effect of that action on various metrics (money, public opinion and cases of disease).

Two independent variables were manipulated; frame position and feedback type. The task was framed either towards internal or external solutions, in one of three ways. There was either No Frame (NF), a frame presented in the instructions henceforth referred to as an Overall Frame (OF) or a frame presented in the questions themselves referred to as a Question Frame (QF). Feedback was presented as either Numeric data (N) such as money lost, or as qualitative statements (Q) of the same thing.

All feedback was predetermined and there was a linear progression through the task, but participants were informed that there was an element of chance to their performance, that there might not be a 'good' solution to a dilemma but rather a 'least bad' one and that their actions could affect later events. This was to increase ecological validity. Additionally, all participants underwent certain pretesting measures and completed post-assessment questionnaires assessing authoritarianism, extraversion and risk taking (see later in this chapter for details).

Questions

11 questions were devised that plotted the outbreak of a potentially dangerous disease at a festival. The first five questions were relatively innocuous, dealing with aspects of simple festival management – late acts, facilities breaking down – whilst the latter 6 dealt directly with the growing outbreak problem and the various issues that arose as a result, either directly or indirectly (See appendices thirteen, fourteen and fifteen for examples, or the accompanying CD for the full text).

Each decision was designed so that the choices were valid in both directions – internal and external. The solutions proposed were selective and as realistic as

the strict division forcing an either/or choice by nature allowed. They were designed to be seen as plausible and viable and this was tested through piloting. All of the questions' choices were derived from real-world occurrences and procedures. Most importantly the questions were designed to be perceived to matter and have consequences. To further this end, they were intentionally descriptive in nature; contextual information that did not necessarily relate to the choice itself was presented to give a sense of place and immersion.

Framing Effects

The frame used was a direct translation of the Asian flu example used by Kahneman and Tversky (Tversky & Kahneman, 1981). This was chosen both for the reasons that they cited (statistical equivalence, reversibility etc) and also precisely because it has been repeated used and demonstrated as robust. In this case, external solutions were used consistently as the 30% chance of success, and internal as the 1/3 guaranteed to be saved, whichever direction the frame was applied in. For counterbalancing purposes there were both internally favouring and externally favouring frames for question frame and overall frame conditions. Both directions were framed identically, or as close as was possible with grammatical limitations and considerations of phrasing.

The overall frame was presented as part of the task instructions and was described as a general property – that external solutions would succeed 33% of the time or that internal solutions would save 1/3 of whatever was at risk. For the Question Frame the frame was presented as part of the decision description at the end and put across in the terms of the question ("33% of the beer will be saved")

Feedback

Three Metrics of feedback were presented for questions: 'Money', 'Reputation' and 'Cases'. These were chosen as important to a festival (money and reputation) or relating to the task problem (cases). Money and Reputation were present for the entire exercise, whereas Cases only started occurring once the initial cases had been reported in question 4. A pattern of feedback was pre-determined to be a simple pattern of one-then-the-other, in that first an internal solution would be

'correct' and give positive results, and then an external one would. The first question was an exception to this, rewarding either choice equally, ensuring that both frames started off being rewarded in the same way regardless of choice.

The metrics were balanced so that an approximately equal amount of 'money', 'reputation' and 'cases' was awarded or taken away for internal or external choices – that is that if a participant were to use solely one or the other option they would receive the same amount of positive and negative feedback, and also the same intensity. For each question a set amount of 'money' and 'reputation' was available and the gain or loss of these depended on the choice made. For 'reputation' this was exactly balanced with gains and losses varying between 1 and 3 % for each question equally for internal and external over the set. For 'money', the gains and losses were balanced, but not perfectly as above – rather slightly random numbers were used - £4004 and £4037 on different questions for instance approximately balancing each other but giving the impression of being randomly generated to sustain the illusion of chance in the task. Additionally, there were a pair of questions (7 & 8) where both choice resulted in numerical losses, with one losing less than the other. Cases was treated slightly differently, in that they could not 'lose' cases once they had developed, but rather there were simply different levels of 'new cases' presented, and these were similarly balanced between conditions (see appendix seventeen).

The above describes the numerical condition. For qualitative feedback, the numerical amounts were described as Slight, Average, Significant or Very Significant Gains or Losses (see appendix sixteen).

Programming

The experiment was designed and run in Microsoft Visual Studio 2010. Participants used a netbook and mouse to navigate through the task. An initial participant number box was filled in by the experimenter, but from this point until the end of the task participants had complete control of the task.

Each question was presented as a separate page, with the descriptive text above a pair of buttons for the internal or external solution, with a standard, brief description of that choice on the buttons ('Wait for car' or 'Start walking' for

example) and a seven-point radio button Likert scale for expressing confidence below that. Participants had to click a 'continue' button to proceed, and could not do so until they had made a selection of choice and confidence (see appendix eighteen). A feedback page was then presented, consisting of two buttons – 'get feedback' and 'continue'. Clicking 'get feedback' would cause the appropriate text to appear, and similar to the question page it was impossible to proceed without clicking to get feedback first (see appendix nineteen). Every click performed in the task prompted a line of code to be generated in a unique excel spreadsheet for each participant. This detailed the Question number, Page type, Event type, Time and current choices (for internal/external and confidence).

Pretesting

Each participant underwent pretesting, filling in three standardised questionnaires that measured Introversion/Extraversion (Francis, Lewis, & Ziebertz, 2006) (see appendix nine), Authoritarianism (Kelman & Barclay, 1963) (see appendix eight) and Risk Taking/impulsiveness (Patton, Stanford, & Barratt, 1995) (see appendix seven). These were taken to test if there were personality traits that would be confounding factors for the experiments. They were controlled for post-hoc as it was impractical to do so beforehand. Authoritarianism was measured because the task presented the possibility for simply deferring to (outside) authority on each choice. Risk taking was controlled for because one set of choices could potentially be seen as the 'safer' option (presumably the outside authorities). Introversion/Extraversion was not predicted to be a confounding variable, but rather was taken to serve as a baseline non-predictive measure.

After the experiment, participants filled in a brief questionnaire that their confidence about the task, which type of solution they felt they had used more and which feedback metric they made the most use of. Additionally there were a series of open-ended questions about how they felt their performance had been, what they might have changed and their general perspective on the task.

Grouping & Participants

The experiment was divided into equal groups based on the two feedback conditions (Numeric and Qualitative) and three framing condition (Neutral, Over-Frame and Question Frame). In both of the framed conditions, groups were counterbalanced to account for frame direction (Internal or External) which added an additional two groups for each of these conditions, making a total of ten groups.

60 participants were tested, with six in each of the ten conditions. Each group was gender-balanced with three men and three women in each, and all the groups were age balanced as participants were collected. Ages ranged between 63 and 19, with a median of 23 and a mean of 26.1. There were no significant differences between groups on the basis of age.

Hypotheses

The experiment had three hypotheses.

Firstly it was predicted that participants decisions would be affected by framing. Both the overall frame and the question frame would influence the decisions made, although the overall frame would be less effective for later questions.

It was also predicted that framing would affect confidence, with framed decisions being more confident than unframed.

Finally it was predicted that feedback type would not affect the decisions made or confidence.

Results

The information gathered was analysed in turn, primarily consisting of the pretesting measures, decisions made, confidence ratings, timing data and a few additional miscellaneous tests.

Pretesting Measures

The scores for each of the pretesting measures (Authoritarianism, Introversion/Extraversion, Risk) were totalled and sorted by subject and experimental results. The population of subjects was divided into the top half

and bottom half of results for each measure and these groups were then compared according to experimental results.

Using confidence as the independent variable, a series of Mann Whitney U tests were performed and no difference was found for any of the factors. Additionally, correlations were performed for the average confidence and pretesting scores. No relationships were found.

When testing for differences in decision making, a series of chi-square tests was performed. No difference was found for the introversion/extraversion measures, or authoritarianism. There was, however, a difference in the choices made for risk taking, $c^2(1, N = 660) = 5.605$, $p = 0.018$.

More risk adverse participants chose an internal solution 46% of the time, whilst more risk seeking participants chose internal 37% of the time. This indicates that participants saw the internal solutions as being more risky than external ones, a reasonable finding given that the situation is depicted as being a serious one that would naturally attract the attention of outside authorities.

As a result of this finding, a Kruskal-Wallis test was performed on the distribution of risk taking scores between the different groups in the experiment. It was found that there was no significant difference between groups. This indicates that whilst risk-taking does have an impact on the decision made, this particular trait was distributed evenly through the experiment population. As a result, it can be assumed that although it is a potentially biasing factor, risk-taking does not predict or account for any of the differences observed.

Decisions

The decisions (internal/external solution) made by all participants were taken and sorted according to experimental group and decision made. A series of chi-square tests were then performed to compare between groups for significant differences. Tests were performed using the No Frame data as a baseline to compare against for all groups, but were also performed comparing between type of feedback (Numeric and Qualitative) and directly between framing types (Overall Frame, Question Frame). The proportions in the Neutral condition were

50 external to 82 internal – approximately 62% internal. This shows that despite the attempt to pre-balance the questions there was an underlying tendency towards internal solutions before any framing occurred.

No difference was found between conditions for the choices made in the Over-Frame condition, either between the two different frames or comparing either to the Neutral condition (Figure 5.1).

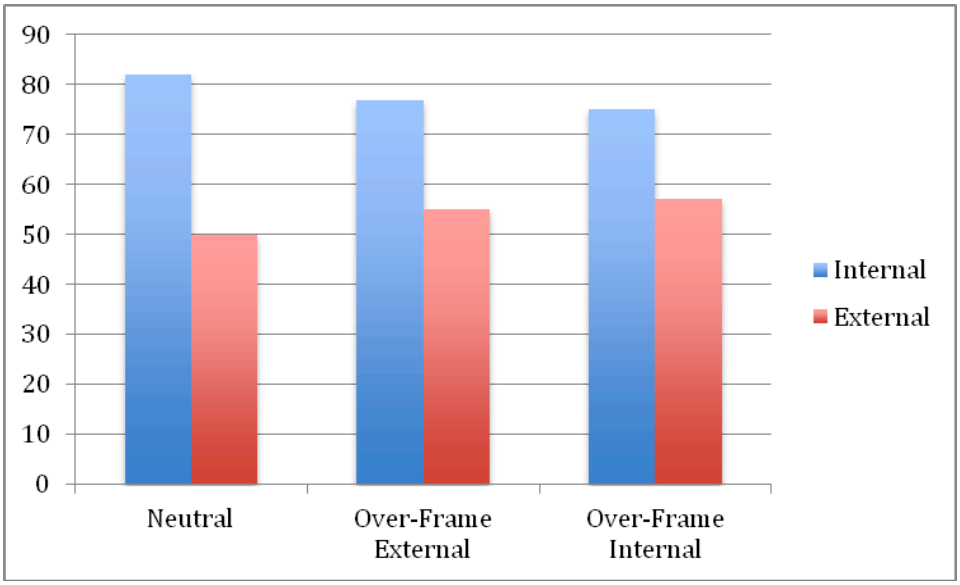


Figure 5.1: Number of Choices made (y-axis) by condition (x-axis) and choice type (Internal/External) for Overall Frames

Significant differences were observed in the Question-Frame condition between the two frame types (c^2 (1, N = 264) = 45.019, p = .000), and between the internal frame and the Neutral condition (c^2 (1, N = 264) = 7.174, p = .007), and the external frame and the Neutral condition (c^2 (1, N = 264) = 17.519, p = .000). Additionally, the percentage change of choices was calculated for both framed (the percentage shift in decisions given the Neutral condition as a performance baseline and therefore the different amount of decisions that it was possible to change given the initial lopsidedness) and was found to be very similar – 40% for the internal frame and 41% for the external frame (Figure 5.2).

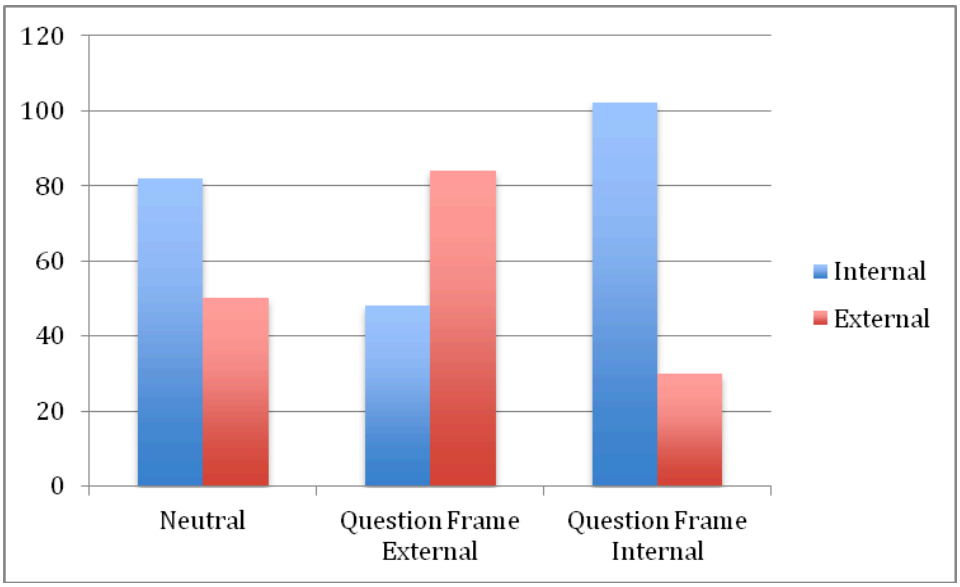


Figure 5.2: Number of Choices made (y-axis) by condition (x-axis) and choice type (Internal/External) for Question Frames.

The data was also analysed by splitting the results according to feedback type, but no significant differences were found either overall or within individual conditions.

These results were then charted by question (Figure 5.3).

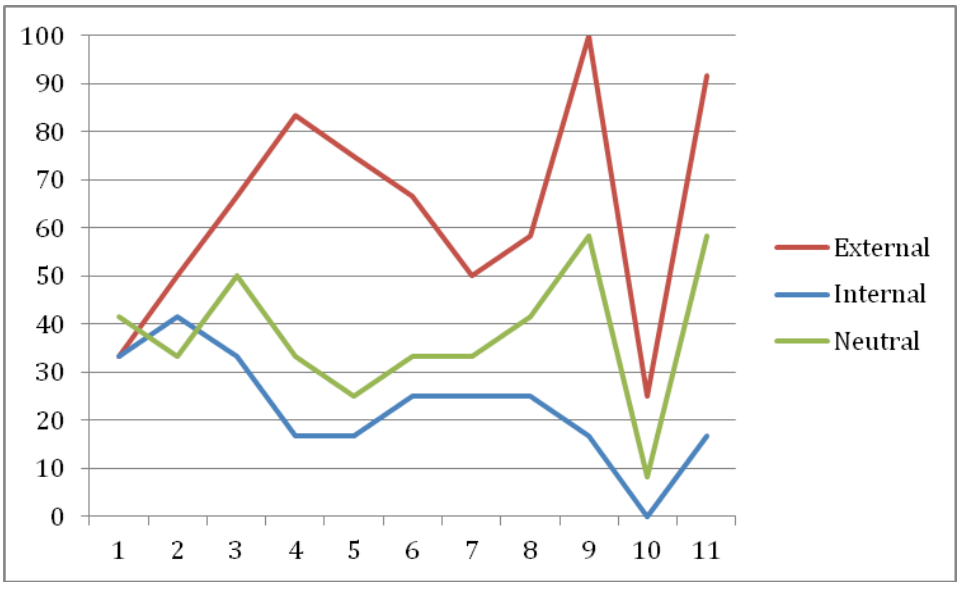


Figure 5.3: Percentage of 'external' choices (y-axis) by question number (x-axis) and condition type (External/Internal/Neutral) for Question Frame data.

The Over-Frame data was also graphed in this manner, as shown below (figure 5.4).

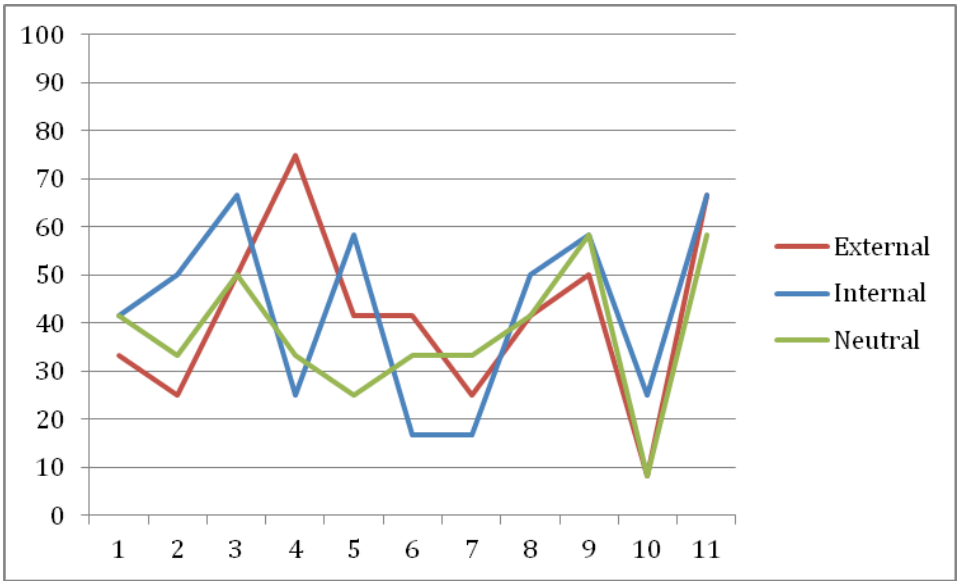


Figure 5.4: Percentage of 'external' choices (y-axis) by question number (x-axis) and condition type (External/Internal/Neutral) for Overall Frame data.

Comparing between the two graphs, it appears that the framing effect is consistent in the Question Frame condition. In the Overall Frame condition, there appears to be noisier data for the first six questions, and relative consensus for the last five.

Statistical note

It is necessary at this point to take a moment to explain the approach taken in regards to some data analysis in both this chapter and the next. An occasional issue with data obtained for this thesis is that the data from various sources did not fit the assumptions of normality and homogeneity that are required for parametric statistics even after transforming the data.

The experimental design was a direct fit for a 3x2 ANOVA and there does not exist a consensus over the best way to analyse non-parametric data in this form. A Kruskal-Wallis test is commonly referred to as 'the non-parametric ANOVA', but it is only designed for analysis along one dimension. The Mann-Whitney U test is a widely used non-parametric comparison of means, but brings with it the risk of making type 1 errors when repeatedly applied

Where a transformation did not resolve the issue of assumptions being violated, an ANOVA is performed, but these violations noted. A series of Mann-Whitney U tests are then reported along the dimensions of the ANOVA to compare the data set means individually.

In this way it is believed that the use of ANOVAs will hopefully account for false positive results from the mass of Mann-Whitney U tests despite the violation of homogeneity, and the use of Mann-Whitney U tests that the ANOVA result was not inaccurate despite failing to meet assumptions of homogeneity. By engaging over several dimensions and showing consistent results it is believed that the results are demonstrated to be sufficiently robust for discussion.

Confidence Data

Having examined the direct choices made, the confidence scores for each participant were then taken and sorted by frame type and feedback type. The ANOVA failed the test of homogeneity with raw scores, and no data transformations could successfully normalise the data.

A 3x2 ANOVA with Frame (Neutral, Over-Frame, Question Frame) and Feedback (Qualitative, Numeric) as between subjects factors revealed main effects of Frame, $F(2, 654) = 6.397$, $p = .002$, $\eta p2 = 0.19$, and Feedback Frame, $F(1, 654) = 11.897$, $p = .006$, $\eta p2 = 0.12$. These were qualified with an interaction between Frame and Feedback, $F(2, 654) = 26.446$, $p = .000$, $\eta p2 = 0.5$.

A series of Mann-Whitney U tests were performed to compare between individual groups. Comparisons were limited to comparing between groups which had at least one factor in common (frame or feedback), as comparing where both were different would introduce too much variability to the process.

Significant differences were found between the Neutral frame and the Over-Frame ($U = 14108.5$, $p=.002$, $Z = -3.165$) and Question Frame and Over-Frame ($U = 30870.5$, $p = .019$, $Z = -2.348$), however no difference was found between Neutral and Question Frames overall.

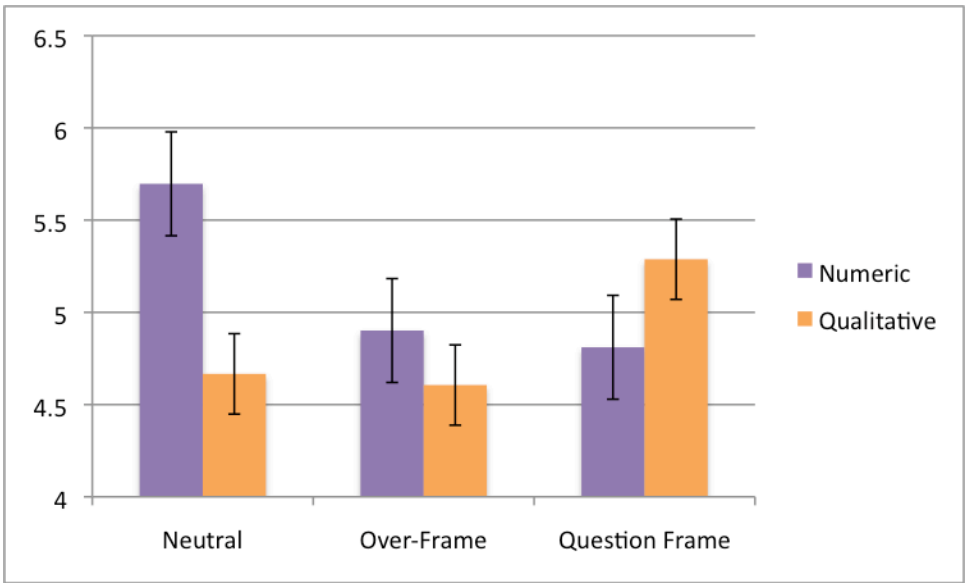


Figure 5.5: Mean Confidence (y-axis) presented by Frame (x-axis) and Feedback Type (Numeric, Qualitative) for all participants. Error bars show standard error.

No significant difference was found comparing between feedback types overall, but significant differences were found between feedback types within all conditions - Neutral (U = 1284, p = .000, Z = -4.165), Over-Frame (U = 7526.5, p = .049, Z = -1.966) and Question Frame (U = 6497.5, p = .000, Z = -3.726).

Within the numeric feedback condition differences were found between the Neutral and Over-Frame groups (U = 2884.5, p = .000, Z = -3.97), and between the Neutral Question Frame groups (U = 2434.5, p = .000, Z = -5.224). However, no difference was found between the Over-Frame and Question Frame groups.

Within the qualitative feedback condition differences were found between the Question Frame and Neutral groups (U = 3303, p = .004, Z = -2.86), and Question Frame and Over-Frame groups (U = 6020, p = .000, Z = -4.500). No significant difference was found between the Neutral and Over-Frame groups.

The confidence data was also analysed on a question-by-question basis, but did not reveal any notable results. There were differences between individual questions, as would be expected, but there were no interaction with other factors. Confidence was also tested according to how confidence varied as a result of the choice made – in whether participants were more confidence when going with a frame than they were against it. There was no difference found

between the groups for either framed group or overall, nor was there any interaction with feedback type.

Timing Data

As part of the experimental setup, timing data was captured for every moment when participants clicked a button or otherwise interacted with the program. This data can be used give an idea of the thinking times involved in a problem, but is not straightforward to use for several reasons, and necessitated the use of several normalising techniques that will be explained first.

Background

The experimental setup had participants exposed to an entire page when considering a problem. Because there was no distinction between the period in which participants were reading the problem description and the period in which they were thinking about which choice might be more appropriate, there was no direct 'thinking time' metric. Timing data was, however, available for the entire page, that is the time taken from the point at which the participant entered the page to the point at which they left. This time was transformed for the purpose of statistical comparison.

Reading time, speed and text length were all controlled for. Reading speed was assessed by using the instructions sheet as a baseline. The time taken to read the instructions was taken, and then divided by the number of words read for each condition (as there were additional words in the Over-Frame condition instructions, and the Question Frame condition questions). This produced a time per word (TPW) metric that could then be directly compared between conditions.

An independent samples t-test indicated that scores were significantly higher for the Over-Frame condition ($M = 275.91$, $SD = 107.74$) than the unframed instructions ($M = 225.24$, $SD = 63.34$), $t(34) = 2.29$, $p = .045$, $d = 0.58$. Levene's Test indicated unequal variances ($F = 4.33$, $p = .042$) so degrees of freedom were adjusted from 58 to 34. No differences were discovered between feedback type, as was expected.

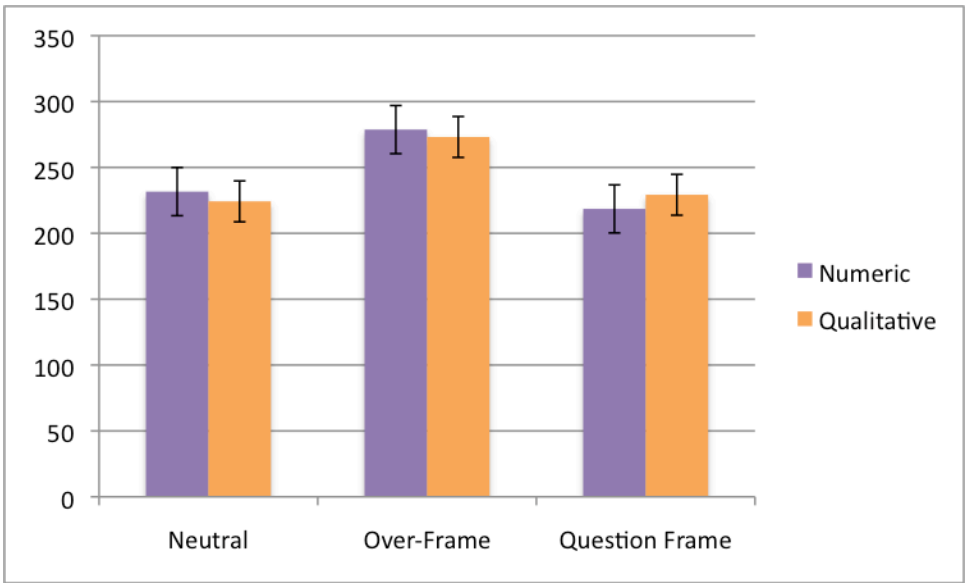


Figure 5.6: Time Per Word (y-axis) by frame type (x-axis) and feedback type (Numeric, Qualitative). Error Bars show standard error.

The results suggest that participants in the Over-Frame condition are spending more time thinking about the instructions they have received, and not simply as an artifact of having read more words. Secondly, the Neutral and Question Frame conditions are statistically the same for reading speed, suggesting that there is a reasonable expectation that the groups are apt for comparison and the Over-Frame result is not simply the result of natural variance in reading speeds.

These scores were therefore used as the baseline for a reading and comprehension speed. That there was also comprehension occurring was not considered a problem, since the level of new information was the same for all participants, except the Over-Frame condition. In order to provide a baseline for that condition, the average difference between the Over-Frame and all other scores was taken, and the Over-Frame results reduced by that amount.

TPW scores were then generated from the question pages for all participants by dividing the time taken by the number of words in that given question. This gave an idea of thinking time for each question, but were still potentially distorted by different reading speeds. Hence, the raw TPW scores from the instructions was used as a baseline to project an expected speed, and the difference between this score (Question TPW) and the baseline score was calculated. This difference in

score was then converted to a proportion of the baseline TPW, and it was this value that was tested.

Analysis

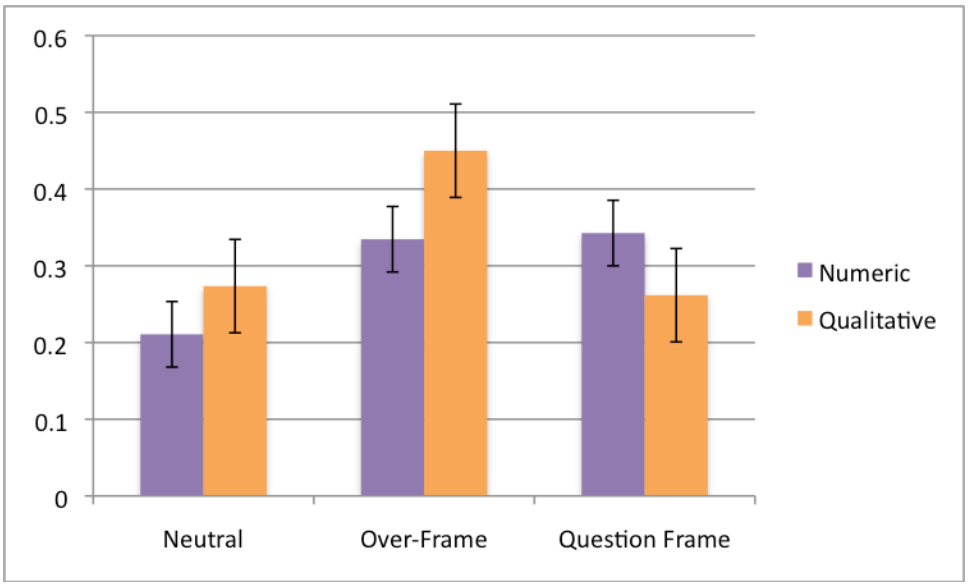


Figure: 5.7 Proportion Change in TPW between Instructions and Questions (y-axis) by condition (x-axis) and Feedback Type (Numeric, Qualitative). Error Bars show standard error.

Because the data was converted into a percentage, it was not appropriate to perform an ANOVA on it. A series of Mann-Whitney U tests showed some effect however. The Neutral and Over-Frame conditions were different (U = 15102, Z = -2.16, p = .031), as were the Over-Frame and Question Frame Conditions (U = 31327, Z = -2.01, p = .045). No difference was found between the Numeric and Question Frame conditions. There was no difference between feedback for the Neutral and Over-Frame conditions, but there was one for the Question Framed condition (U= 7340, Z = -2.212, p = .027). A correlation was found between percentage TPW change and confidence by Spearman's rho (r = -.086, N = 660, p = .027) suggesting that when participants were more confident they took less time to make their decision.

Spearman's correlation also found a relationship between percentage TPW change and question (r=-0.174, N=660, p=.000) indicating that as participants completed the task they took less time considering their answers.

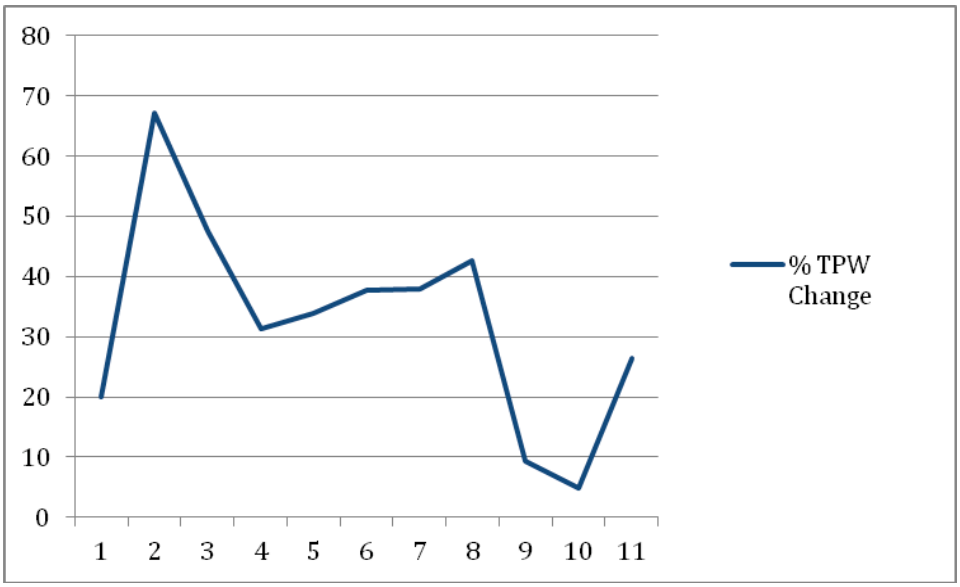


Figure 5.8: Mean Percentage Time Per Word Change from Baseline (y-axis) by Question number (x-axis)

Finally, a correlation between confidence and question number was not found.

Frame Direction Effects

As noted previously, the frame direction had an effect, in that participants were less likely to choose external solutions on a general basis, as seen in the baseline condition, and that risk-adverse participants chose more external solutions than internal.

Again, the data was in percentage form and thus inappropriate to be assessed by an ANOVA, but it was graphed, and a series of Mann-Whitney U tests performed on it.

Significant differences were found between conditions for an external frame ($U = 6983$, $p = .005$, $Z = -2.787$) and between frame types within the Over-Frame condition ($U = 6150$, $p = .000$, $Z = -4.13$). A difference was also found between External and Internal frames overall, ($U = 27853$, $p = .000$, $Z = -3.991$).

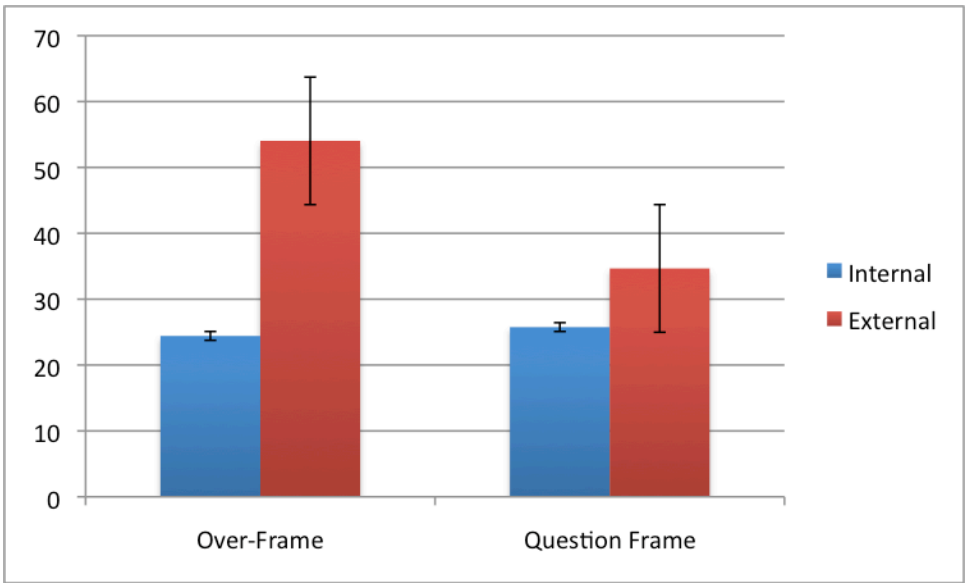


Figure 5.9: Mean Percentage Time Per Word change between Baseline and Question measurements (y-axis) by condition (x-axis) and Frame Direction (Internal, External). Error Bars show standard error.

Feedback Time

Timing data was also gathered for the feedback data. Feedback was obtained by clicking a button to see it, and then another to proceed once read. This had the effect of isolating the period in which participants were considering the feedback, removing the ambiguity that existed in distinguishing between reading time and thinking time. The limited amount of information presented as feedback similarly eliminated the need for reading times to be accounted for as there were no long strings of text to be read and understood.

The raw time data was therefore taken, and converted into its logarithmic form to ensure homogeneity of variance. A 3x2 ANOVA with Frame (Neutral, Over-Frame, Question Frame) and Feedback (Qualitative, Numeric) as between subjects factors analysing (logarithmic) time revealed an interaction between Frame and Feedback, $F(2, 654) = 4.177$, $p = .016$, $\eta p2 = .013$.

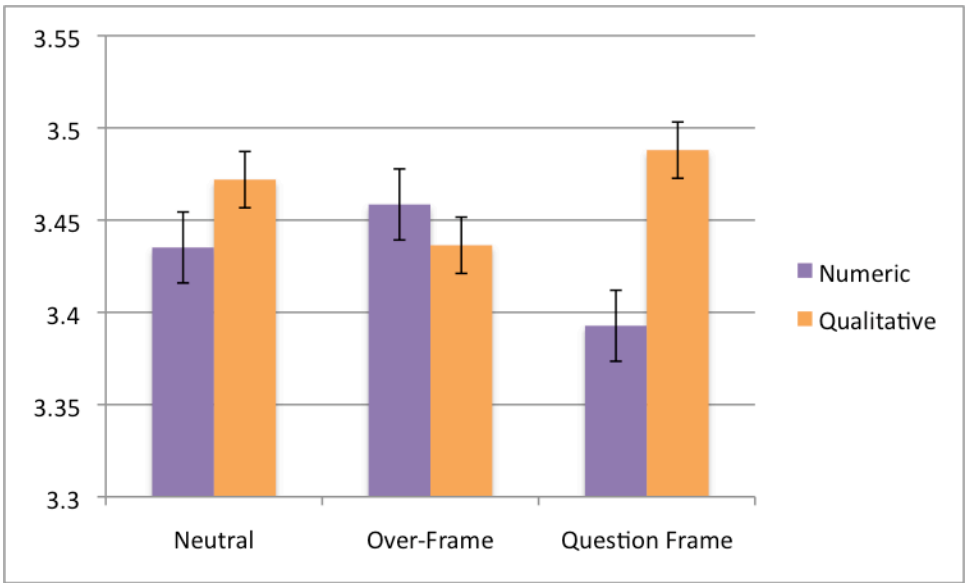


Figure 5.10: Mean Logarithm of Feedback time (y-axis) by Frame Type (X-Axis) and Feedback Type (Numeric, Qualitative). Error Bars show standard error.

A series of Mann-Whitney U tests were performed comparing between the individual data points. A significant difference was found between the numeric and qualitative scores at the Question Frame level (U = 6759, p = .002, Z = -3.148). Neither of the other levels showed a significant difference.

Discussion

As the preceding section has hopefully made clear this study has provided a wealth of data to be analysed and understood. This section will seek to tie together the various analyses and make clear what overall conclusions can be made.

First the initial hypotheses that were suggested will be evaluated. Following this, specific conclusions will be drawn about the data and what it seems to tell us about how integration occurs, and also how confidence interacts with framing effects over time. Ongoing implications for the proposed model will then be discussed, before new questions that this study has raised will be addressed.

Hypotheses

The three hypotheses can now be assessed.

Firstly it was predicted that participants decisions would be affected by framing. This was supported in the case of the question frame, but no significant differences were observed in the overall frame condition. The inconsistency of choices in the first six questions in that condition possibly suggests an effect of a different type however.

It was also predicted that framing would affect confidence, with framed decisions being more confident than unframed, and feedback type would not affect the decisions made or confidence. It was found that framing did affect confidence, but as an interaction with feedback. The results proved to be more complicated than the hypotheses predicted, and this will now be discussed in more detail.

Complexity

Beyond the specific hypotheses there was a basic expectation that framing would have an effect in this environment as it did in the card game paradigm. This was strongly supported. Effects were seen between framing conditions and between feedback types for decisions made, confidence scores and timing measures. However as noted above the results differed from what was predicted. Framing was only present at the question level and feedback had an impact on confidence and timing measures. The results contain a number of interactions, suggesting that one of the main conclusions that can be drawn is that of complexity, and that the results in this area go beyond simple causal relationship.

The results from the confidence metric are significant in this observation. Firstly because it is a potentially 'hidden' attribute – that it was observed here because it was looked for, but may also have been a factor in previous work and gone undetected. This provides evidence that framing has properties that need to be understood in terms of an ongoing scenario, and also in broader terms than simply the either/or choice dichotomy they have generally been studied in. Secondly it should not be concluded that this is therefore the totality of how framing can affect the decision making process, but rather evidence that framing could potentially impact on multiple factors beyond just the decision made, of which confidence appears to be one. Results from timing data support this idea,

that different cognitive processes are occurring as a result of framing and interactions with feedback. The relative simplicity of the effect in single-choice examples does not extend to a more dynamic system. And this experiment was relatively controlled and constrained – it must be anticipated that more complicated relationships could exist in scenarios with still greater ecological validity.

Framing Position Effects

Contrasting the neutral and Question Frame conditions, an effect is readily apparent - the Neutral condition provided a baseline reaction that the Question Frame 'stretched' in the direction of that frame. What was not expected was that it maintained that pull over the entire experiment – there was no evidence of frame fatigue, or participants becoming 'wise' to the constant frame they were being exposed to. From the previous experiment's results it was anticipated that over time participants would rely more on feedback than the frame (as the frame would become transparently biased once repeated enough) and revert towards the Neutral baseline, but there was no evidence of this.

Additionally it was expected that the frame would be most potent for the initial problems, but this was again not the case – if anything it took a couple of questions for the frame to start significantly affecting decisions. Given that this frame has been effective in a single-decision context previously, it seems most likely that this initial failure of the frame is due to the ongoing scenario paradigm. What appears to be occurring is that the frame as presented takes time to be integrated into the overall decision making apparatus (providing yet more evidence that this was, in fact, seen as a whole task rather than a series of individual decisions). This explanation would also account for the non-failure of the frame later on, when repetition would have been expected to lessen its effects.

The Over-Frame condition failed to frame participants at all, but did appear to have an effect, as the initial six question choices were unpredictable between conditions. This was despite the Question Frame participants mirroring the baseline pattern, and over-frame participants showing that same mirroring later

on (also implying that the effect faded with time, consistent with it being a result of the frame). The effect of the Over-Frame may therefore have been to disrupt the decision making process for the first few questions of the task. The questions this raises is why would this happen, and why no framing occurred.

It is hypothesised that this was due to new information affecting the decision making process, but not being clear enough to be systematically biasing or framing. If we believe from the question condition that it took time for the bias to be fully integrated into the decision-making, then it would follow the converse could be true, and in this case the frame was never fully integrated and understood. In addition to only occurring once as opposed to repeated framing (as in the previous experiment) the frame was by necessity presented in abstract terms of 'external or internal' solutions. The information was not contextualised any further or linked to anything specific in the questions. So whilst participants were aware that there had been additional information imparted, they may have been unsure exactly how to apply it. They may also have been confused about which solution was 'internal' and which 'external' – although it was intended to be apparent, not labelling the actual solutions as actually being 'the internal solution' may have cause participants to be unsure of how the frame applied.

What these different conditions really point to is the need for integration in order for frames to be effective. In the case of the Question Frame, the condition took a couple of questions for the information to be integrated and as a result a couple of questions for the framing to be predictive. In the Over-Frame the frame never became integrated for whatever reason, although it was known by the participants so it had the effect of confusing the decision making process as a result of a lack of integration.

Integration

This study provides further evidence that the traditional understanding of framing effects and bounded rationality is insufficient to explain activity in more dynamic environments. That should not be taken to say that previous research is not useful; clearly the Asian flu framing utilised in this study, and the series of framing mechanisms employed in the previous example are drawn from pre-

existing literature and demonstrate that they are still effective in ongoing tasks. However, the way in which frames work in this different context clearly has a number of unique properties to it that demand further study.

The emerging pattern, as noted above, appears to be that integration is key. That is, that both a task and the frame must be processed and understood in order for the frame to have an effect on the task. Evidence of this was seen in the previous experiment where the frame was not applied to discarding when it could have been, then furthered here where framing took some time to be established in the Question Frame condition, and a lack of integration disrupted decision making in the Over-Frame condition at the start of the experiment. Integration is proving to be a key way for explaining if frames are effective (or ineffective).

This makes sense on a basic level – it is necessary to understand in order for it to influence your decision making after all. However in all the examples given, it was not that the information failed to be understood at all. Indeed, in the card game study discarding was understood as a mechanism and implemented with only small mis-steps at times. Similarly in this experiment participants understood the instructions – they did not ask for clarification and expressed no confusion afterwards. What is going on is not a simple failure to process, or even a failure to understand on a basic level, but rather represents a failure to grasp the implications of the information and apply it appropriately.

The significance of this finding has several aspects. Firstly it actually identifies a large part of why we would anticipate framing effects to have a different impact in ongoing scenarios – they have a lot of moving parts and complexity. The significance of this should not be underestimated; if integration at a relatively high level is key, the busier and more cognitively demanding the environment the greater the possibility that a frame could get lost in the milieu. It may be that framing fails to have an effect not because the frame itself is badly designed or incapable of affecting something, but in a given context it simply does not generate enough attention to be effective.

This raises the question of how frames are attended to, and therefore integrated into a participant's understanding. Fortunately this experiment provides a useful

example of just this with the Question Frame. Here the same frame was fully integrated into the question, both in terms of describing the proportions in terms of the problem at hand, but also in terms of being part of the text that participants were engaged with reading for an understanding of the problem. The information was there, it was available and it was part of the process already. This raises questions about how separate a frame can be from the information it is relevant to.

Additionally there arise issues in regards to predictability and forecasting of behaviour. Often when applying psychological theories to practical situations it is necessary to hedge probabilities anyway – if exposed to this stimulus, 70% of people will respond in a particular way, or 60% of participants generally respond favourably to a particular sort of therapy. However what this experiment illustrates is that with framing a different sort of calculation applies. The question is not only how participants will react to a given frame, but also whether the frame will be integrated and thus applied at all.

In this experiment it was a perfectly reasonable prediction, based on previous experience, that inserting a frame into the instructions would be sufficient to create a noticeable and statistically significant difference. That this was not the case was unexpected, but in a manner that is perfectly consistent with the developing understanding outlined in this thesis. However, the nature of that understanding is that it is difficult to predict ahead of time exactly what will be integrated or not. A set of properties can probably be assembled to aid with this task, but given that even in this relatively controlled environment it was hard to do, it is likely that increasingly realistic environments would provide increasing levels of challenge for that prediction. As the complexity increases the possibility that some other factor with interfere with expected integration increases also.

As a result of this, it seems prudent to suggest that this is seen as a two-stage process for such predicting. The effectiveness of a frame should be evaluated as one factor, but as a separate (although interacting) factor, the level of integration should also be assessed. In this experiment it was the integration level, not the type of frame that primarily accounted for the differences between conditions,

given that the frames were mathematically identical. The danger this illustrates is that care must be taken not to reject a framing approach as ineffective due to the frame itself, rather than a lack of integration.

Integration can therefore be seen as a new dimension to be studied for bounded rationality. In the same way that Kahnemann describes a partial list of properties that can affect availability for decision making, it is not hard to envision a list of similarly defined properties that would start to map the landscape of what affects integration for framing effects. Indeed, it would be thoroughly unsurprising if these properties also turned out to represent more generic properties of perception and decision making. What framing could represent here, then, would be the means by which integration could be studied. Given a consistent bias that is known to exist with an established frame, variable levels of potential integration could be set and their effectiveness gauged by their effectiveness in framing. Indeed, it would be interesting to know if integration and/or framing are binary propositions, or if it would be possible to create a partial or lesser framing effect through partial integration.

Confidence

The second important overall observation to come out of this study concerns the confidence measure. It was both readily accepted and understood by participants, as well as displaying effects. These demonstrate that it was a useful and relevant factor to be measuring, as well as apparently accurately capturing what it was intended to, lending confidence to its appropriateness. Some conclusions can be drawn from its use.

Firstly, confidence varied systematically by condition. The broader implication of this is simply that when framing a concept in order to drive opinion, it is likely that confidence will be impacted at the same time. Decisions may be affects, but this change will come with additional consequences - people may be more or less enthusiastic about the choice they are making, and more or less willing to take risks as a result of it. When framing opinion, simply determining the direction in which a decision will now go is not sufficient to predict the outcome of the

actions that will be undertaken. Framing will affect not just what is done, but also how it is done, and these additional factors are just as important.

Noting 'additional' factors plural in the previous paragraph was not an error. That confidence is affected is the only statement we can be confident of currently, but everything about that result suggests that other elements could have similar properties. It is reasonable to hypothesise, as has been done earlier, that confidence is not the only factor that is likely to be affected by framing. But it is also true that the factor that we do have solid evidence for – 'confidence' could itself be unpacked. It was a variable that was deliberately left broad and for interpretation by the participants, but it would not be difficult to imagine that it might be parsed into more specific aspects of that concept. Alternatively the behaviours it might influence could be separated and differentially examined. In the risk questionnaire used in this experiment, different types of risk factor such as physical or financial were identified and available to be rated separately. With this data set, parsing the results further by that metric would have resulted in low power and potentially uneven groups, but further work might find that framing more specifically targets financial concerns than it does physical ones, for instance, and that this affects the confidence as a result.

What is also notable about confidence is that it didn't simply vary by condition, it interacted according to feedback. The same points about a variety of factors that might affect confidence could be made about feedback type, and it should be noted that this is further evidence of the potential complexity of framing in a dynamic environment. However regardless, the more significant result is that framing did not have a generic raising or lowering of confidence effect. This is another example of the need to contextualise any understanding when looking to make predictions about responses, or relative confidence.

If this understanding can be contextualised and made robust enough for a given situation, the understanding could be used to systematically affect the performance of actors in a given setting. From the data above we know that framing can affect confidence, and we know that response time correlates with confidence – the more confident you are the faster you make a decision, and the

less confident the longer you take. It is not hard to see how this could be applied in, for instance, a combat scenario. If a frame can be introduced to the opposing force through the use of propaganda or other means it does not even have to actually affect the decisions that the people who read it make. They could make the same decisions at the same places, but do so every so slightly slower, as a result of the frame. And in a combat situation those critical decisions – when to move, where to move, whether to open fire – can literally be life or death depending on split second timing.

Implications for the Model

The implications this work raises for the model are essentially supportive. The step of integration, in particular, is looking more and more important as studies continue. This raises the possibility that as a step it is, in fact, too simplistic. The information in the initial model is understood simply as an either/or state, but increasing evidence is that this is not the case. Things can be perceived and integrated to a degree (such as the discarding rule, or the Over-Frame in this example) and not go on to influence decision making. Participants were clearly aware of some things so therefore they must have been integrated on some level, but not sufficiently for that understanding to have the expected influence. Recognition of the complexity of this step will be necessary, some discriminatory mechanism for determining how and why different elements are integrated to a different degree.

New Questions

This experiment raises a number of questions to be addressed, as well as opening up potential avenues of future research, some of which are too wide-ranging to be addressed by this thesis at this point.

The most basic question to be taken forwards is one of integration and future influence. In this experiment much has been made of the difference in integration between the two attempted framings, with the suggestion that this is true at a planning level, with the frame having been integrated into decision making biases. If this is true, there should be an effect (or effects) seen as a result of removing the frame and posing the same sorts of questions. If there is really

integration, lingering frame effects should be seen. Additionally, to date the framing effect has been established only when presented as part of the problem to be solved. Given that this is unlikely to be the case in the real world, if the frame can be presented as a secondary source of evidence and be integrated into the decision making still there will be greater cause for confidence at the effectiveness of utilising this understanding in real world situations.

Secondly there are further questions of applicability and ethnographic validity to address. Between the card game and this study, the phenomena have been robustly established, and steps can be taken to apply the understanding to an ongoing area of research.

CHAPTER SIX – Frame Persistence and Cyber Influence as a Framing Mechanism: The Herbal Study

Introduction

Previous chapters have examined the effect of framing on strategic behaviour in tasks. This chapter will re-utilise the previously employed series of forced choices and confidence measures, whilst employing a different framing mechanism employed in a more ecologically valid manner and exploring whether effects persist once the frame is removed.

Setting

The same basic paradigm was employed as the previous experiment, with the significant difference that the framing mechanism was removed from direct association with the problem description. A social media feed was chosen to fulfil this role, being both easily separable from a problem description and a source of potential influence with significance in the real world.

It is a common assumption that social media plays a significant role in driving behaviour. Examples of this include relatively innocuous activities such as the coordinated mass-buying of a song to get it to number one in the UK(News, 2009), and more significant global events such as the 'Arab Spring' series of uprisings and unrest in the middle east (Howard, 2011; Saletan, 2011) and the UK riots of 2011 (Halliday, 2011).

Research has not address the idea that such sites can be framing, but have concluded they are influential to some degree. Studies have explored how users share and promote physical exercise via the site (Kendall, Hartzler, Klasnja, & Pratt, 2011), how academics cite on it (Priem & Costello, 2010), and even how Governments use it (Wigand, 2010). There have also been efforts to understand the mechanisms driving such interaction and their effects. Studies have looked at using it to examine current attitudes and beliefs (Marshall & Shipman, 2011), and questions have been persistently raised about whether the information

being shared is accurate or not (Castillo, Mendoza, & Poblete, 2011; Mendoza, Poblete, & Castillo, 2010) and established that influence within twitter is distributed and not limited to 'authoritative' sources(Bakshy, Hofman, Mason, & Watts, 2011). For these reasons, social media presents a real-world example of a source of information that is potentially influential and could plausibly be framing.

Design

The experiment consisted of two parts: a series of questionnaires and a computer program that participants completed.

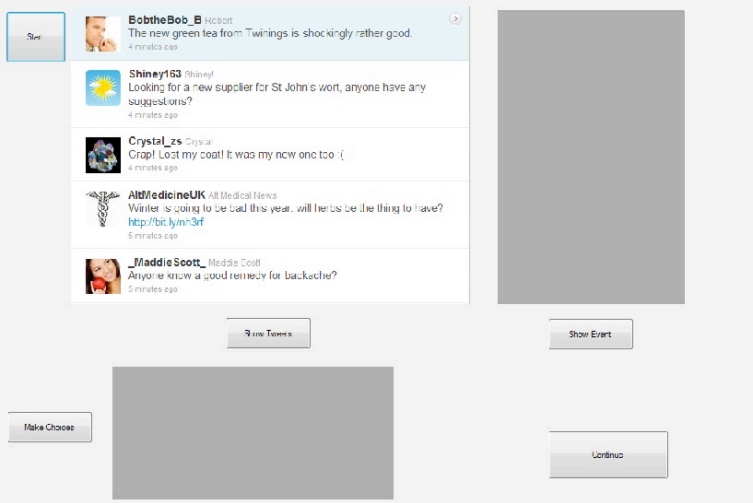
There were four questionnaires, three of which were administered prior to the experiment, and one that afterwards. The three beforehand consisted of likert scaled questions that measured attitudes to alternative medicines (see appendix twenty), introversion/extraversion and risk taking (Francis et al., 2006; Patton et al., 1995) (see appendices seven and nine). The I/E and risk sheets were the same measures used in the previous study standardised from prior research. Risk and attitude to alternative medicines were measured as potentially biasing factors. Introversion/extraversion was measured as a baseline: it was not expected that it would have an effect on the task. The alternative medicine sheet was constructed specifically for this work as there were no standard measures available, and was intended as a rough guide. It was administered on the assumption that pre-existing biases towards the subject matter would exist, although the experiment was designed such that this should not have been a factor. A final questionnaire covering use-of and attitudes towards social media was administered at the end of the experiment (see appendix twenty-one).

Method

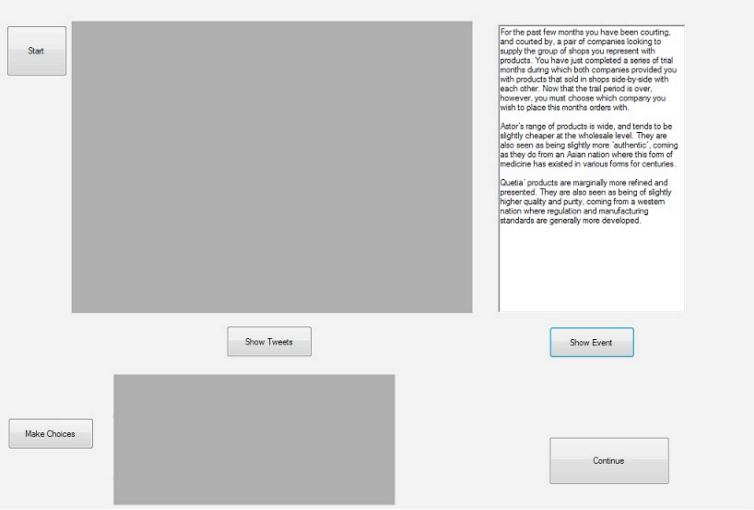
The task consisted of a series of thematically linked binary choices, paired with a confidence scale. There were 18 questions in total, divided into three sections: an initial eleven questions, a final five and then two 'rethink' repeated questions. The first section would consist of the framed questions (apart from in the neutral condition), with the framing effect achieved by a mocked-up Twitter feed. There would then be an 'event'; a framed non-response event followed by the final five

questions, where there would be no framing. After this, two questions would be re-presented to the participants.

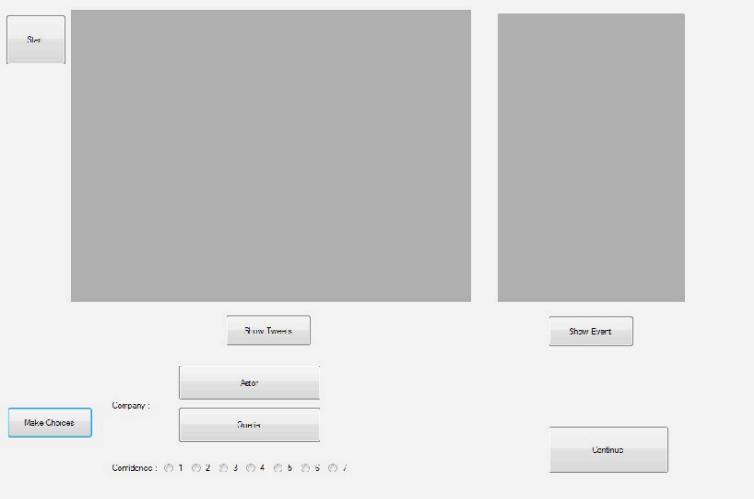
For each choice, the computer screen would show a participant three grey panels, with a button beneath each labelled as ‘show tweets’ ‘show decision’ and ‘make choice’ respectively (see figures 7.1-7.3). Participants began the section by pressing the start button to the left, which would first display the tweets. Participants then had to view the decision next by clicking on its button, at which point as it was revealed the tweets were re-concealed. After this they could proceed to the decision making section, which consisted of two buttons (one for each company) and a seven point Likert scale measuring confidence. Participants were free to view whichever section they wished for as long as they liked, and return to them as many times as they wished, but at any one time only one section was visible. Every time any button was pressed, the program recorded timing, choice and other relevant data.



Picture 6.1: Screenshot of an example test screen, with Twitter feed currently visible



Picture 6.2: Screenshot of an example test screen, with the scenario text visible



Picture 6.3: screenshot of an example test screen, with choice buttons visible

The setting of the task placed the participant in the role of a buyer of alternative medicine products (specifically herbal remedies) for a cooperative group of shops. For each decision, participants were required to choose between two fictional companies that they could order from. These were Quetia, located in an Antipodean nation and representing slightly higher cost but greater quality and Astor, located in Asia and representing slightly cheaper products and greater authenticity (see appendix twenty-two for the experimental instructions). These distinctions were intentionally given as mild and were not intended to be biasing, but rather to add a greater sense of realism to the task. The series of decisions through the experiment described both a series of small, unconnected dilemmas and choices, but also an overarching narrative about a contaminated batch of a product that both companies produce causing sickness (see appendix twenty-four for an example decision). The event described the eventual outbreak of widespread problems associated with this and was framed in the manner of the Asian flu example (see appendix thirty). The remaining five questions then dealt with repercussions, differing reactions to the problem and cleanup.

Progression through the questions was linear: all participants received the same questions in the same order. They were told, however, that their responses and decisions affected what happened and the questions that were asked as a result. This was done intentionally to motivate participants to think of the task as a single task rather than a series of individual decisions.

Feedback was provided after each choice was made according to two metrics, retailer confidence and profit. Both were described qualitatively as variations of 'small/medium/large' loss or gain. The exact combinations of these metrics varied between questions in order to give the illusion of random chance, which participants were told beforehand existed but in reality there was none. Both conditions were balanced such that if a participant chose only one company or the other, they would even out to have the same result (this was true for both sets of questions, before and after the event). Similarly, the actual feedback varied with which choice was 'better' on a linear basis, A-Q-A-Q etc. The

exceptions to this were the first and last questions, which rewarded equally regardless of participant choices. The reason for this was that with both questions, it was desired that participants would feel they had made the 'right' choice whichever they picked. Particularly for the first question it was felt that participants should not begin the experiment being punished for a choice. The effect of this was that a participant that theoretically chose all of one company would see the exact same feedback overall that a participant who chose the other company would (see appendix twenty-three for details).

Framing was achieved via a mocked-up twitter feed. It was chosen to use twitter for several reasons. Firstly it is a recent and well-covered website, ensuring both general familiarity even among non-users as well as reflecting a recent trend in online social networking towards broadcasting. Secondly it is common to simply 'follow' people on twitter for information without being friends with them and knowing them personally (as is often the case with facebook). This makes it more appropriate for the task of 'information gathering'. Thirdly, the relative simplicity of its interface and display made it easier to incorporate into an experiment without seeming totally unnatural.

The frame itself was constructed along the lines of heuristic elicitation, as described by Kahneman and Tversky (Kahneman & Tversky, 1973). In that experiment, a personality description of dubious quality was shown to be given significant weight in determining probable field of study for a student. In this experiment, an information of dubious source and veracity (the twitter feed) was to be used to guide participant's decisions. Participants were informed that the feed represented people being followed, but that they had no greater authority than that.

Each question was accompanied by a non-interactive image of a twitter feed (see appendices twenty-five through twenty-seven for examples). All images were generated by creating the twitter accounts in question, giving them names, generic profile pictures and then having them 'tweet' the appropriate information in a given order before taking a screenshot. For each question, the twitter feed showed five tweets, from the same five twitter accounts.

The information within these tweets was determined systematically. Neutral condition tweets were deliberately chosen to have nothing to do with the experiment or any aspect of it. Occasionally a tweet would comment upon the information from the decision, but never to give an opinion or any actual information about it. For instance when the decision related to the fact that customers were buying less herbal medicine, one of the comments was 'Everyone seems wary of Herbal medicine these days' – a simple re-stating of the decision to come, and not something that should affect the decision. They also contained the news tweets, as described below.

The five tweets that appeared in a framing twitter feed consisted of:

1) A news tweet, stating the decision as news and providing a (non-functional) link to a story.
2) A Pro-frame tweet, restating the pro-rationale made within the description.
3) An Anti-frame tweet, restating the anti-rationale made within the description.
4) A second, novel, pro-frame opinion tweet
5) A tweet giving a statement of *personal* pro-frame behaviour either enacted or anticipated.

The main pro and anti frame tweets were identical between conditions, although they switched roles depending which side was being framed. The news tweet also stayed identical, meaning that the only information that actually changed between the two conditions was the secondary option, and statement of action. In the neutral condition, no biasing information was included either way.

The order that the accounts appeared in the feed was randomized, and then kept constant for each question between the conditions. The order in which the frame information appeared (and thus which account was saying it) was also randomised and kept constant between conditions, meaning that each condition was seeing the same order of pro and anti frame tweets. The news tweet, naturally, was therefore in the same position between all conditions.

Hypotheses

Firstly it was predicted that framing would be seen in this experiment, that the twitter feed would successfully bias participant responses in the intended direction.

Secondly it was predicted that framing effects would be continue to be seen once the frame was removed, as would be consistent with the integration theory proposed in the previous experiment which proposed that a frame became integrated into decision making processes.

Thirdly it was predicted that systematic differences would be shown in confidence, and other sources of data, between framed and unframed participants. It was predicted that framed participants would be more confident than their unframed counterparts when making decisions.

Finally it was predicted that the non-response 'event' would frame subsequent choices, also consistent with the integration theory.

Results

The results from this experiment are taken from a number of measures, primarily the choices made, the confidence in those choices and timing data.

Pretesting Data

All participants were given surveys to complete as detailed above measuring their attitudes towards alternative medicines, risk taking propensity, familiarity with social media and degree of introversion/extraversion as well as gathering general demographic information.

48 participants in total were tested, divided equally into the relevant conditions. There were an equal number of male and female participants in each condition and the experiment as a whole. The age of participants ranged between 19 and 46, with a mean age of 27, and median of 26. Most participants were in some way involved with the university, although there was a mix of undergraduate and

postgraduates. There were no significant differences between any of the groups in terms of age composition.

A subset of the 48 participants was conducted at distance due to difficulty with obtaining participants in-person. This involved participants running the computer program on a PC at their location, and filling out the relevant questionnaire forms in order. It was ensured that all participants were using the same equipment as those tested in person, and whilst the test was being administered they were observed via one-way video conferencing software to ensure that they did not take a break, drink, eat or engage in any other activities that would have biased their results. This subset had a mean age slightly below the average, having a median and mean age of 24. The participants were evenly distributed between the 6 conditions with one in each, and their results were collected and compared to the in-person group results. No significant differences were found in the time taken for tasks, decisions made or confidence, and as a result it was concluded that conducting the experiment at distance had no significant effect on the task.

The different groups were tested between for the survey-measured traits. No significant differences were found between groups for any of the measures obtained. It was concluded that preexisting biases within the groups would not bias any of the results obtained.

The neutral condition participants' answers to the first 11 questions were then used to see if there was a correlation between any of the factors and the choices made. This was done because the traits could still be predictive, even if they were evenly distributed and thus not biasing to the experimental design. The neutral condition alone was used, because the framed conditions would, by their very nature, be biasing over and beyond that which could be predicted by the traits. No correlation was found between the number of times a participant chose Astor and either attitude towards alternative medicine, or introversion/extraversion. A correlation was found, however, between risk taking and Astor choices using Spearman's Rho $r(16) = .567$, $p = .022$. This

indicated that participants saw Quetia as the 'less risky' choice between the two companies, something that will be referenced later.

Choices

For the purposes of this section, the 'choice' in question refers to which company was chosen to buy from for each question.

Totals were amassed for the first eleven questions in each condition: Framed for Astor, framed for Quetia, (subsequently referred to as either A or Q frames) and Neutral. Event conditions were ignored as a factor, since until that point all conditions were identical, and framing only occurred up until the event.

It was found that participants were framed in an approximately 7:3 ratio (framed choice to unframed choice) in both directions. In the neutral condition, participants were split approximately 50-50 between the two choices.

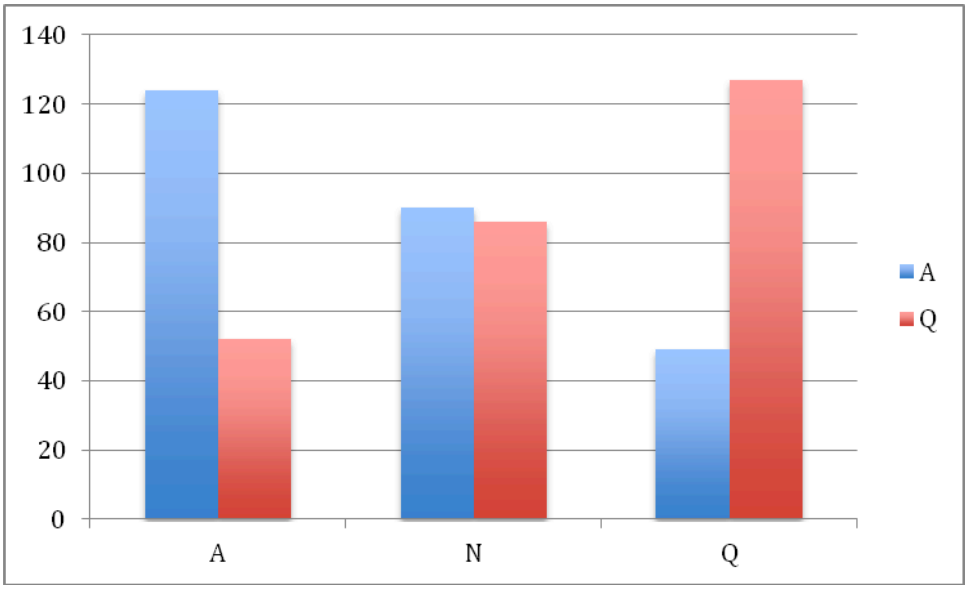


Figure 6.1: Participant Choices (A/Q) (y-axis) by condition (A/N/Q) (x-axis) for the first eleven questions

A series of chi square calculations were performed on the data, and it was found that both the A frame (c^2 (1, N = 352) = 13.78, p = .000) and Q frame (c^2 (1, N = 352) = 19.99, p = .000) choices were significantly different to the neutral condition (and thus to each other). This suggests that the framing was successful

in influencing the decision made and that the frame was approximately equal in power in both directions.

This data was also visualized by presenting the data by question:

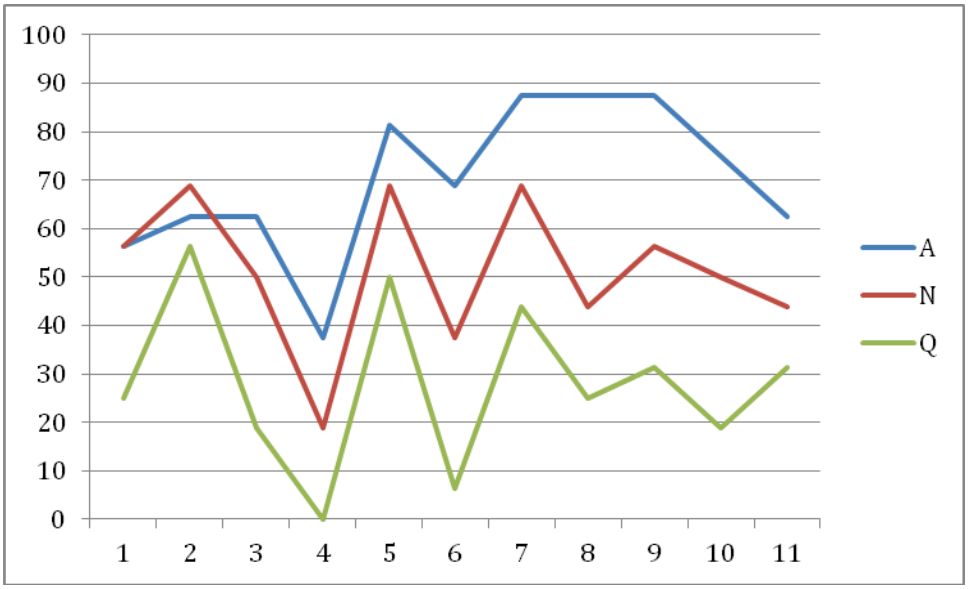


Figure 6.2: Percentage participant choice of A (y-axis) by question number (x-axis) for first eleven questions by condition (A/N/Q)

The same collating of data was performed for the last 5 (unframed) questions. First the data was divided according to the frame applied.

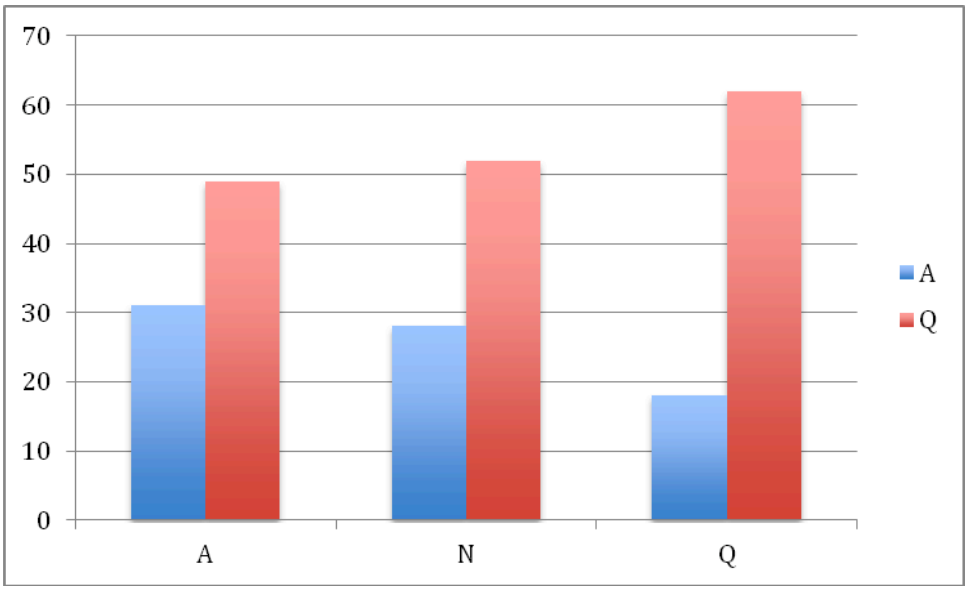


Figure 6.3: Participant choices (A/Q) (y-axis) by condition (A/N/Q) (X-axis) for the final five questions

Comparing either the A or Q frames with the neutral condition does not produce a significant result, however directly comparing the A and Q frames is significant (c^2 (1, N = 352) = 4.97, p = .026). Participants were also compared when split by the event frame (Quetia framed or Astor framed), however no significant difference was found.

The data was also charted according to the difference between the first 11 and last five questions to show relative change towards Quetia between conditions.

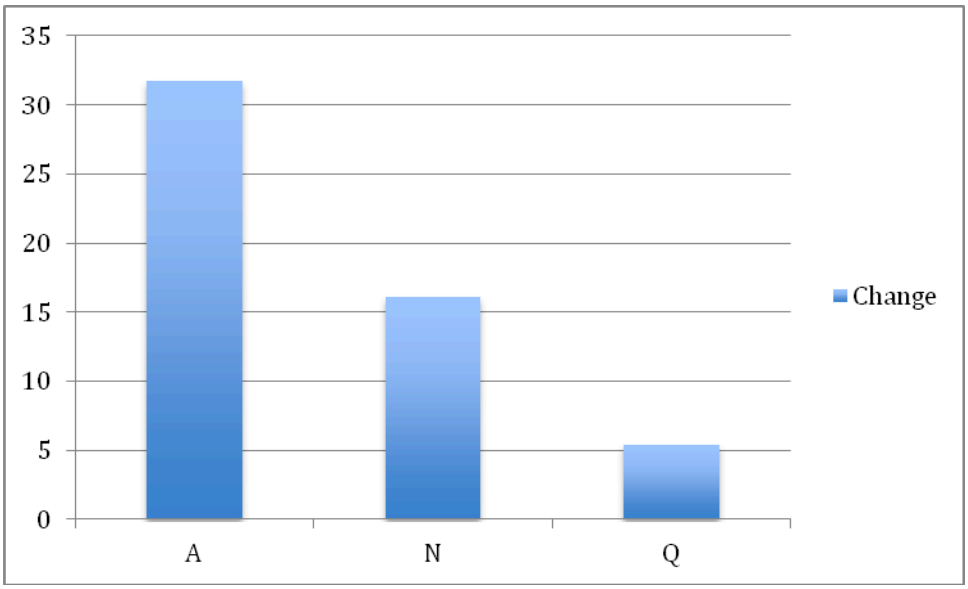
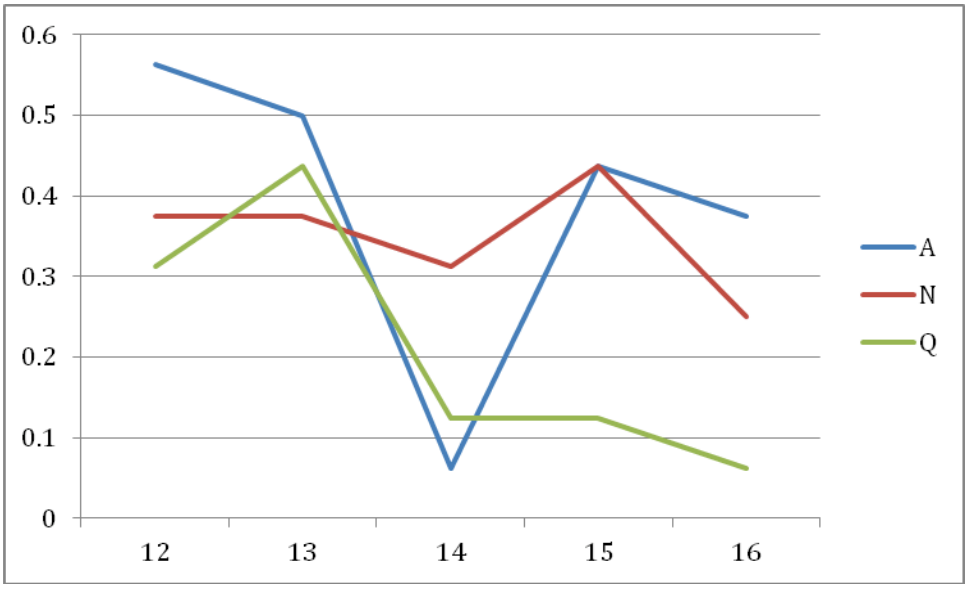


Figure 6.4: Percentage Difference in choices made between the first eleven and last five questions (y-axis) by frame (x-axis), shown as percentage change towards Quetia.

The proportional choice of A was then graphed for the last five questions (Figure 6.5 below).



Firgure 6.5: Participant choice of A (proportion) (y-axis) by question number (x-axis) for final 5 questions by condition (A/N/Q)

Finally, the same analysis was applied specifically to the last question of the main experiment, question 16. This was done because that particular question asked

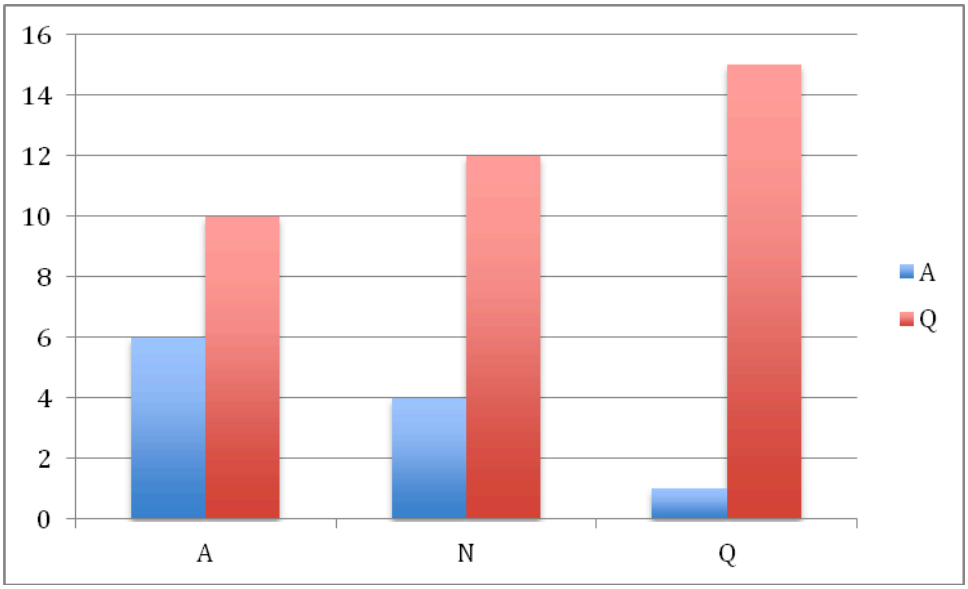


Figure 6.6: Participant choices (A/Q) (y-axis) by condition (A/N/Q) (x-axis) for the final question

participants to make a final choice of which of the companies they would choose to buy off for a year going forwards. Consequently, it can be seen as a 'final preference'.

It was found that although there was no significant difference between the Neutral condition and either frame, there was a significant difference at the one-tailed level between the A and Q frames using Fisher's Exact Test (p=.041). The low number of responses made Fisher's Exact Test more appropriate than a Chi Square in this circumstance.

Confidence

The overall confidence score results pre and post event (first eleven verses last five) were compared for each condition.

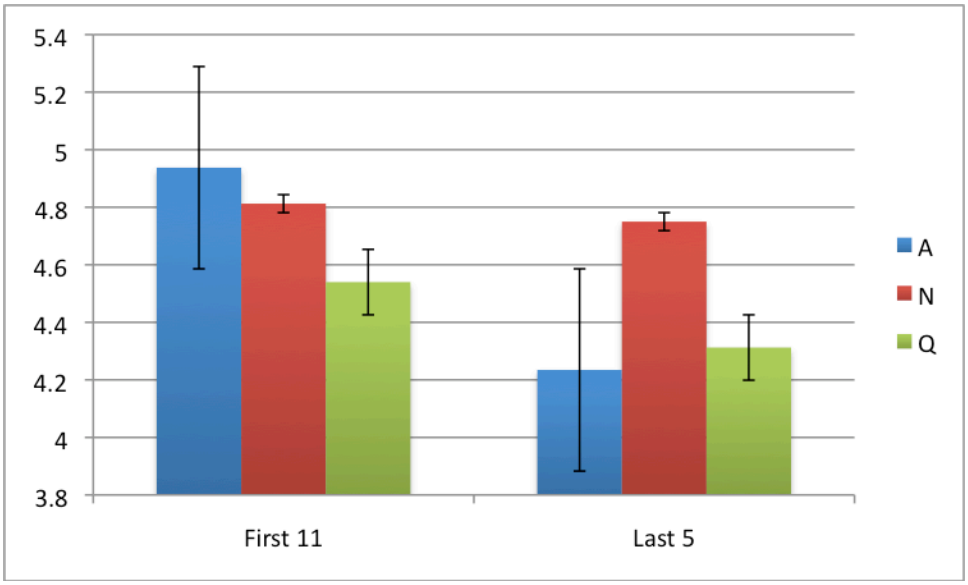


Figure 6.7: Average confidence (y-axis) by condition (A/N/Q) and question set (x-axis). Error bars show standard error.

A 3x2 ANOVA was performed on the data with Frame (A,N,Q) and question set (First 11, last 5) as between subject factors. Main effects were found of question set, $F(1, 762) = 7.10$, $p = .008$, and frame, $F(2, 762) = 3.73$, $p = .024$. These were qualified by an interaction, $F(2, 762) = 3.75$, $p=0.24$. A series of Mann-Whitney U tests found that in the first 11 questions there was no significant difference between the A and N frame conditions, but that Q framed confidence was significantly different to both A framed, $U = 13037$, $p = .008$, $Z = -2.65$, and Neutral conditions, $U = 13397$, $p = .03$, $Z = -2.17$. Between question sets, only the A frame was significantly different, $U = 5203$, $p = .001$, $Z = -3.45$. In the last 5 questions, Both the A-frame, $U = 2552$, $p = 0.24$, $Z = -2.26$, and Q-Frame, $U =$

2637, p=0.48, Z = -1.98, were significantly different to the Neutral condition, and identical to each other.

		Choice	
		Astor	**Quetia**
Condition	**A Frame**	5.00	4.79
	Neutral	4.83	4.79
	Q Frame	4.20	4.67

Table 6.1: Mean Confidence for participant choices by condition in first eleven questions. All figures accurate to 3sf

Confidence was also examine within choices made for the first 11 questions (table 7.1 above) As can be seen from the above table, confidence in Quetia does not vary greatly (or significantly), whether framed or unframed. Confidence does, however, vary significantly, U = 1923, p = .000, Z = -3.878, in Astor when framed.

This was repeated for the last five questions:

		Choice	
		A	**Q**
Condition	**A**	4.26	4.27
	N	4.43	4.92
	Q	4.22	4.35

Table 6.2: Mean Confidence for participant choices by condition in final five questions. All figures accurate to 3sf

No significant differences were found between choices for these questions. Since the variance appears to be mainly in the Astor choices that hypothesis was tested by graphing the above information for each choice type between question sets.

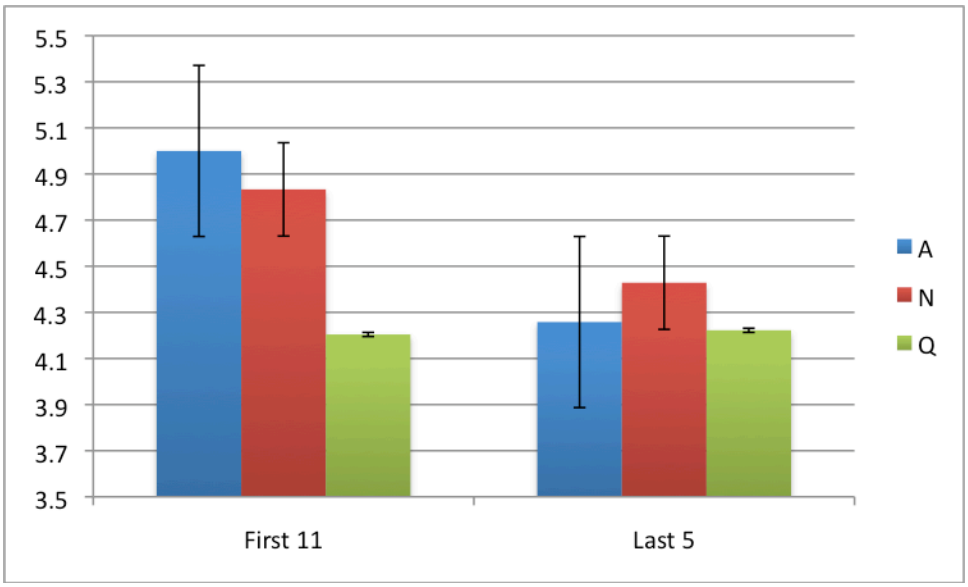


Figure 6.8: Confidence scores (y-axis) for A choices sorted by frame (A/N/Q) and question set (x-axis). Error Bars show standard error.

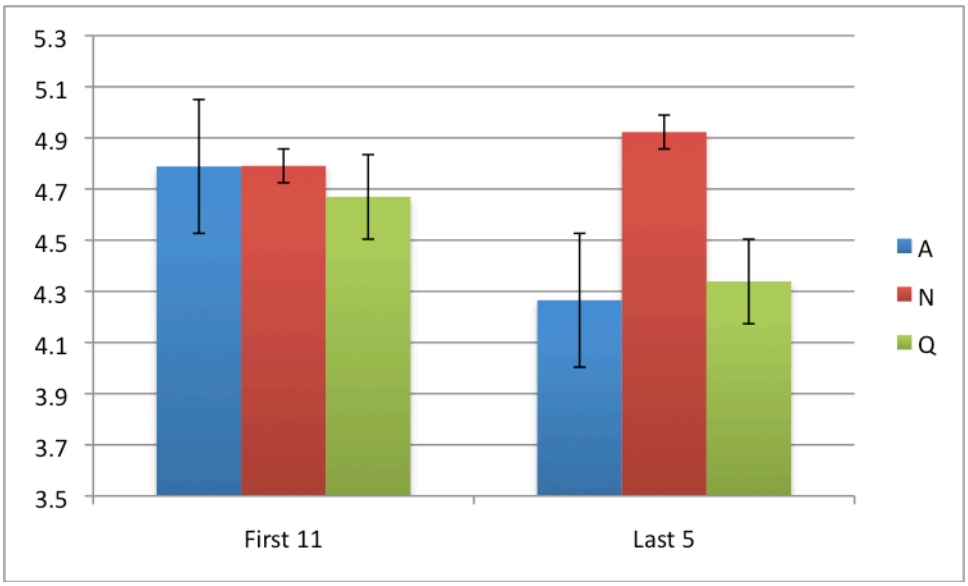


Figure 6.9: Confidence score (y-axis) for Q choices sorted by frame (A/N/Q) and Question set (x-axis). Error Bars show standard error.

These charts appear to show divergence in the first eleven questions for A values, then conversance in the last five. The pattern is reversed for Q values, which are roughly equal for the first 11 questions, then diverge for the last five.

The data was then sorted according to confidence when a choice is made that goes along with the frame (pro-frame) and against it (anti-frame).

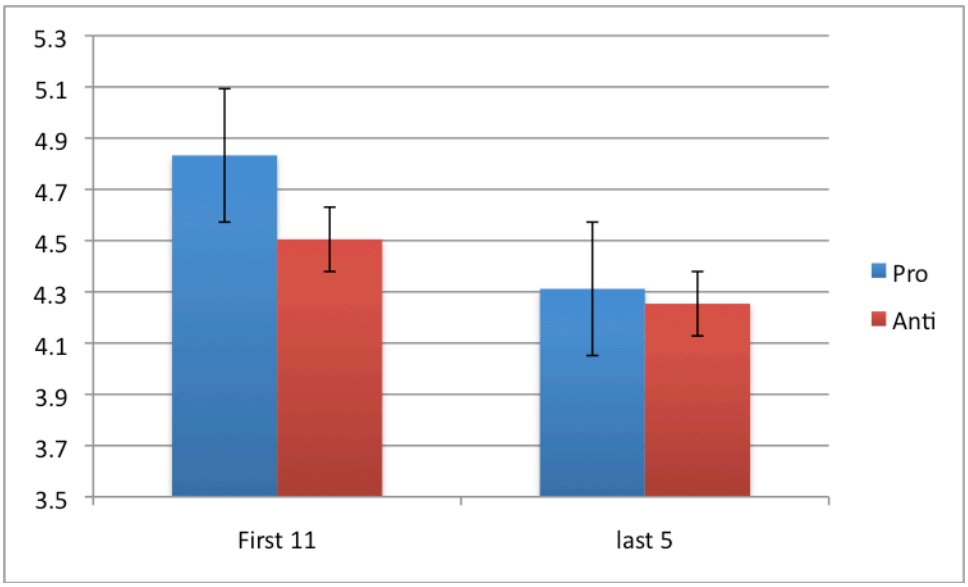


Figure 6.10: Mean framed participant confidence (y-axis), organized by question set (x-axis) and frame-relative choice (Pro/Anti). Error bars show standard error.

There is a significant difference between the confidence participants have when making the choice they have been framed towards or against, U = 10705, p = .019, Z = -2.351. Both groups fall in confidence once framing is removed, but only the pro-frame fall is significant, U = 9391, p = .004, Z = -2.873.

Confidence was then charted by question.

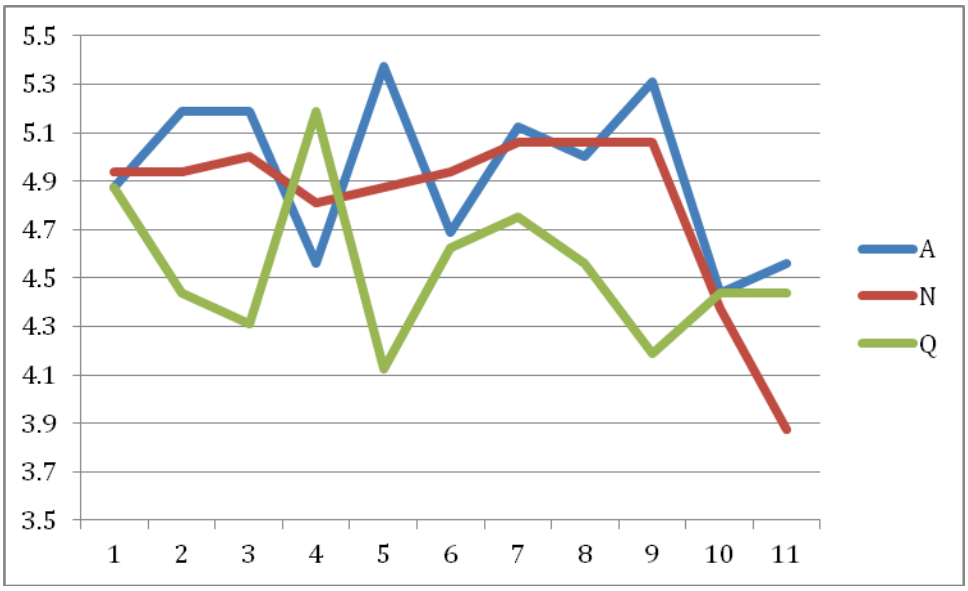


Figure 6.11: Mean Participant Confidence (y-axis) by Question number (x-axis) for each condition (A/N/Q)

Although the data is somewhat noisy, here we see that the confidence of the A and Q frames almost mirror each other, and appears to match up with the pattern of choices by question as seen in the previous section to a degree (Figure 6.2).

The relative lack of noise when unframed can also be seen in the last five questions.

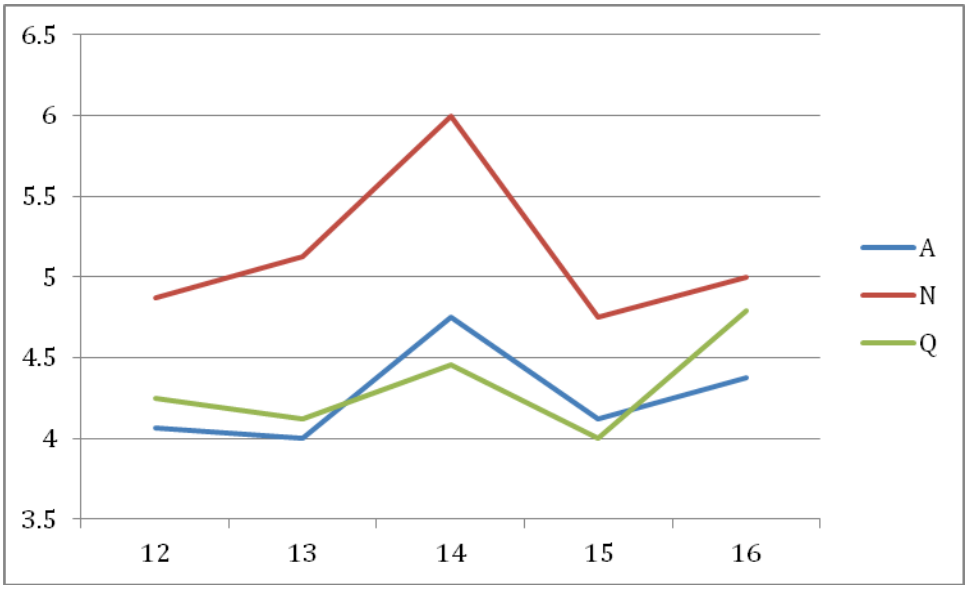


Figure 6.12: Mean Confidence scores (y-axis), by frame (A/N/Q), for the last five questions (x-axis)

Timing Data

Timing data was obtained for all participants as part of the computer program. Times were captured at any point that a participant clicked on a button or made a change in some other manner that caused the program to act. The experiment was designed to isolate the constituent parts of a the decision making process – Tweets, Description and choice button – so that only one was viewable at a time, creating a direct measure of how much time was spent with each. It is assumed that time spent with a given section is an indicator of attention and cognitive resources being used.

Although participants could go back and forth between sections, this analysis creates a cumulative value of the total time for the purposes of analysis. The number of times a section is viewed was recorded separately.

A baseline reading speed was obtained by using timing data from the instructions page. Although not simply a raw measure of reading speed (as there was obviously a comprehension aspect to the task), it was consistent for all participants. For the decisions data, word counts were obtained for each question and used to control for differences created by varying text amounts.

Word count differences were not accounted for in the tweets section, for two main reasons. Firstly, the 140 character limit provided limited potential variability between conditions, and word counts were made roughly equal. Secondly, controlling for text amount makes the assumption that participants will read all the text – reasonable for the decision text, but inappropriate for twitter. More than a few participants remarked that at one point or another they were either skimming or ignoring the tweets, and the nature of a twitter feed is such that participants might well choose to only want to read contributions from one person, or conversely ignore another. Because both of these factors contradict the assumption on which word-count weighting would be undertaken it was not applied.

Choice Selection

The timing data in this section was the time spent physically clicking the buttons that indicated the decision that they had made. Consequently there was no text or other influencing information to be considered: for each and every question the section was identical. The rote task-based nature of this section of the task provides a useful comparison point with the information-processing requirements seen in the other two sections. The data was skewed, as if often the case with timing data, and was log transformed to account for this.

A 3x2 ANOVA was performed on the data with Frame (A,N,Q) and question set (First 11, last 5) as between subject factors. A main effect was found for question set, $F(1, 762) = 23.492$, $p = .000$ only. A series of Mann-Whitney U tests confirmed that the only significant difference was between question sets, $U = 48494.500$, $p = .000$, $Z = -5.217$. There is a slight correlation between question number and time taken $r(766) = -.340$, $p= .000$. Charting the data suggests that

this effect is down to task familiarization. Removing the first three questions removes any statistically detectable effect, supporting this conclusion.

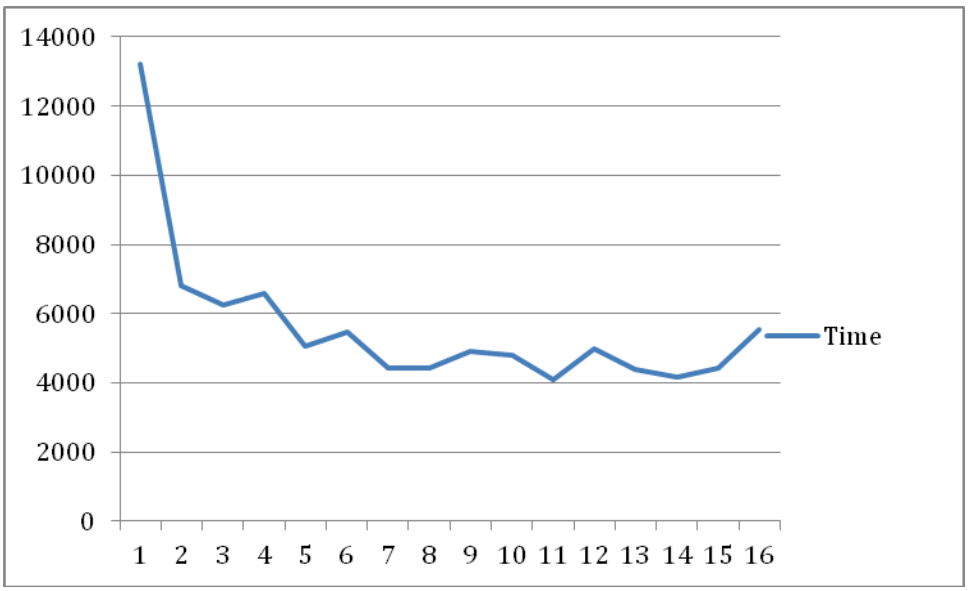


Figure 6.13: Total time in ms that the 'input choice' section is open (y-axis) by question number (x-axis).

There is a slight correlation between confidence and time taken r(766) = -.186, p=.000 (see Firgure 6.13 below) suggesting that certainty about a choice predicts how quickly it is made, as would be expected.

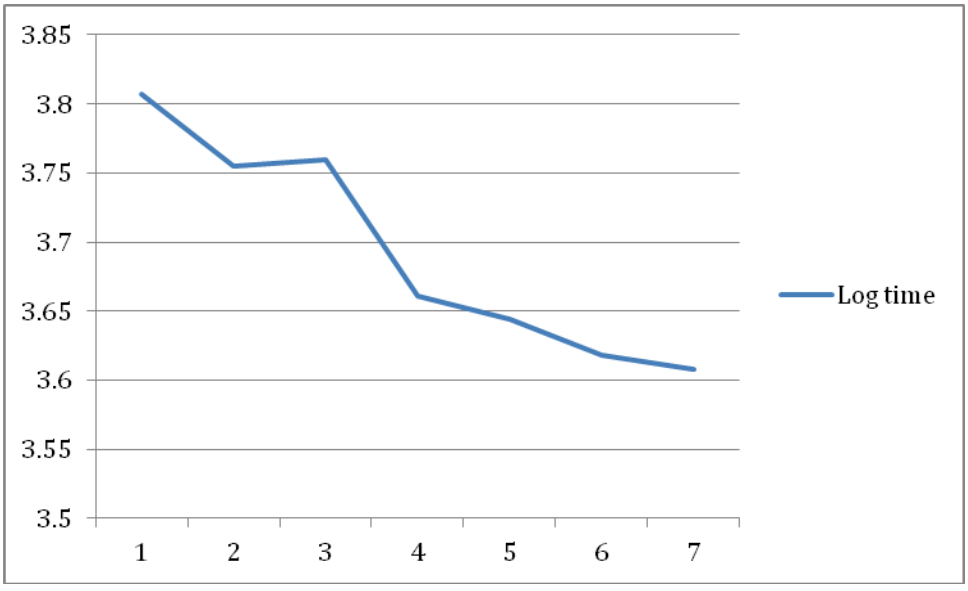


Figure 6.14: Mean time (log transform) taken to make a choice (y-axis) by confidence rating (x-axis) for all participants.

Decision Text Section

The timing data for reading the decision text was treated as described above. It was additionally converted to its logarithmic value in order to fulfill the requirements of parametric analysis.

Comparing the amount of time taken to read the decision text between conditions, it was found that there was no difference between the framed conditions (A and Q). A 2x2 ANOVA was performed on the data with Frame Status (Framed/Unframed) and question set (First 11, last 5) as between subject factors. A main effect was found for frame status, $F(1, 762) = 18.015$, $p = .000$ only. However, both question set ($F(1,762) = 3.164$, $p = .076$) and an interaction ($F(1,762) = 3.342$, $p = .064$) were close to significance, and the test failed Laverne's test of homogeneity.

Examining frequency distributions for this data, it was observed that Although the overall data was distributed in a relatively normal fashion, individual components of the data set were more erratic. Data was still in a generally normal pattern, but had multiple peaks at the same time. This accounted for the failure of the homogeneity test, but also indicated that the near-positive results merited further investigation as the problems were characteristic of a data set that could have been normally distributed with more data points.

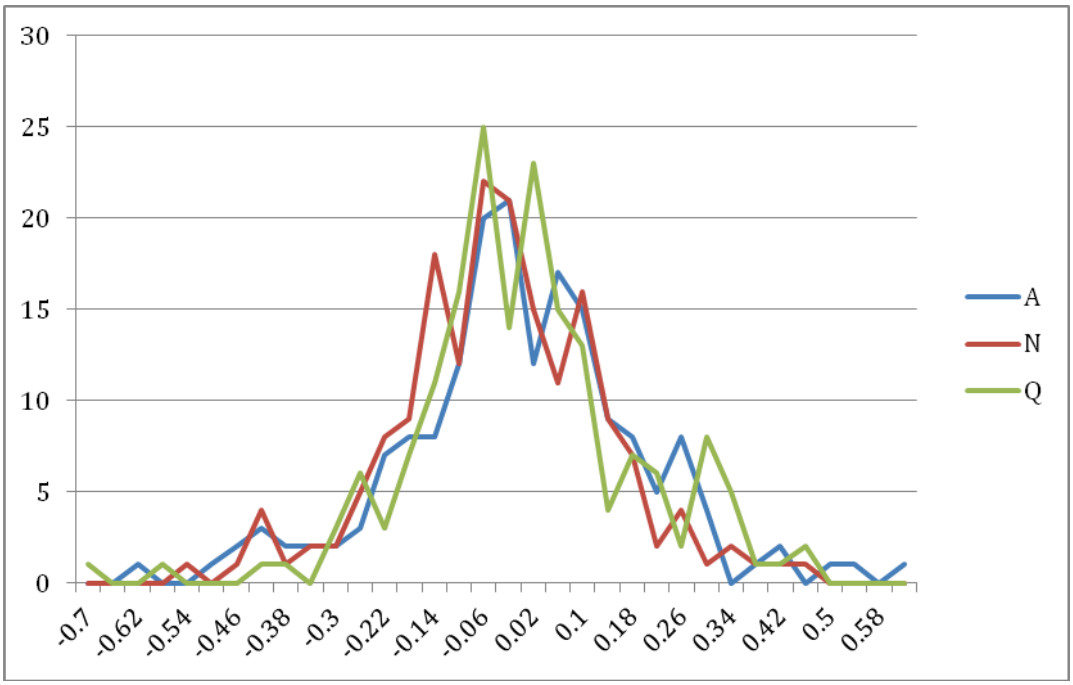


Figure 6.15: Log of mean adjusted time (x-axis, 0.04 increments) frequency (y-axis) by condition (A, N, Q) for first 11 questions

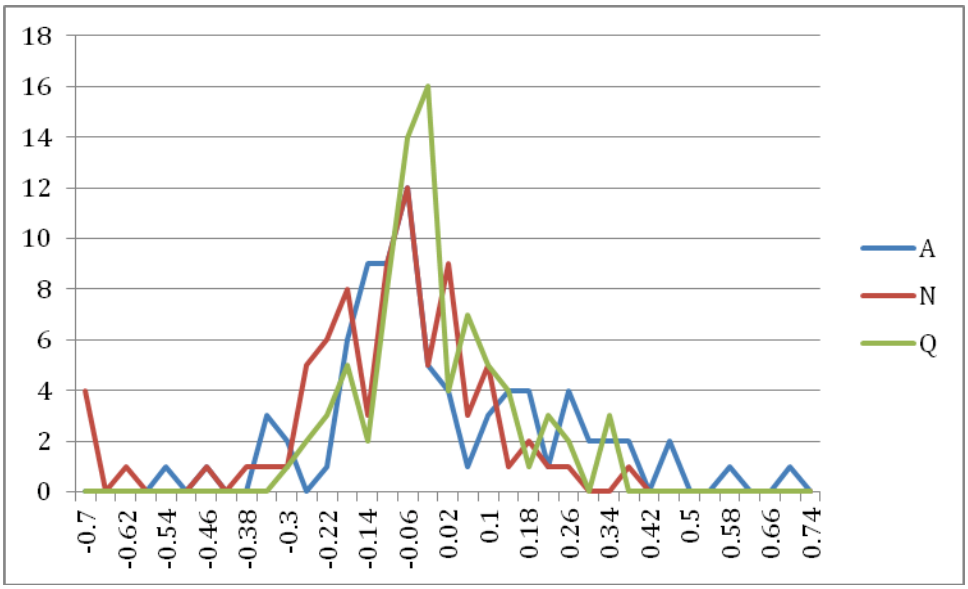


Figure 6.16: Log of mean adjusted time (x-axis, 0.04 increments) frequency (y-axis) by condition (A, N, Q) for last 5 questions.

Consequently, a series of Mann-Whitney U tests were performed on the different data permutations. Significant differences were found between framed and unframed conditions overall (U = 55529, p = .001, Z = -3.453), in the first 11 questions (U = 27607, p = .042, Z = -2.039) and in the last five questions (U =

4772, p = .001, Z = -3.211). Significant differences were also found between question sets overall (U = 56592, p = .018, Z = -2.375) and between question sets in the neutral condition alone (U = 5572, p = .008, Z = -2.673). However, no significance difference was found between question sets in the framed condition. No differences were found between the different frame conditions (A and Q), and therefore framed results were treated as a single condition.

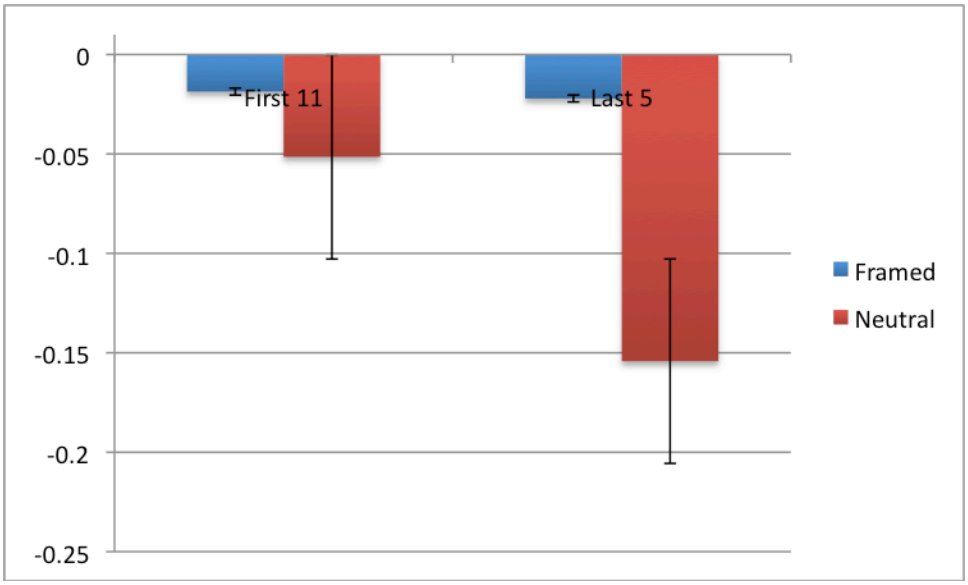


Figure 6.17: Mean Values of log Adjusted time (y-axis) by question set (First 11, Last 5) (x-axis) and Condition (Framed, Neutral). Error bars show standard error.

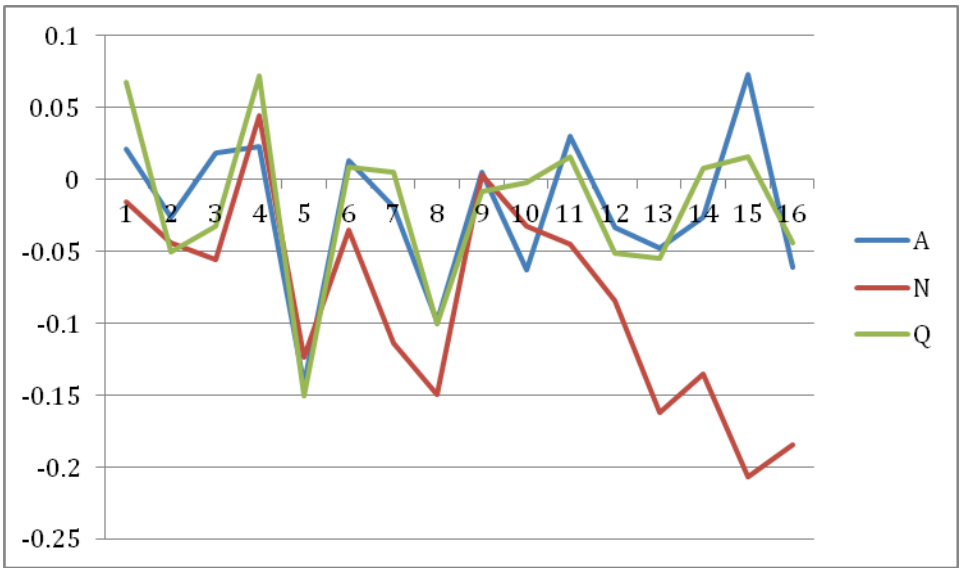


Figure 6.18: Log of mean adjusted time (y-axis) taken for each condition (A, N, Q) to read the decision text for each question (x-axis).

Tweet Times

Timing data for the Tweet viewing was treated in the same manner as described at the start of this section. It was also converted to logarithmic form in order to be able to make use of parametric statistics.

As was found in the Decision timing section, the data was both in need of being transformed, and yet correcting the skew did not correct the lack of homogeneity of variance.

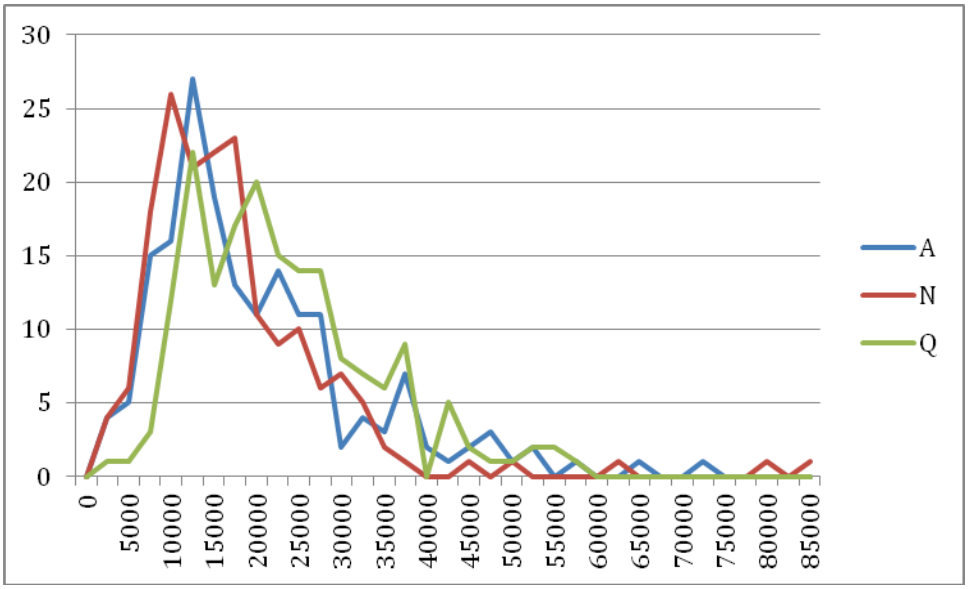


Figure 6.19: Frequency distribution of raw time data in ms (x-axis) by condition (A, N, Q). Frequency taken in 2500ms bins

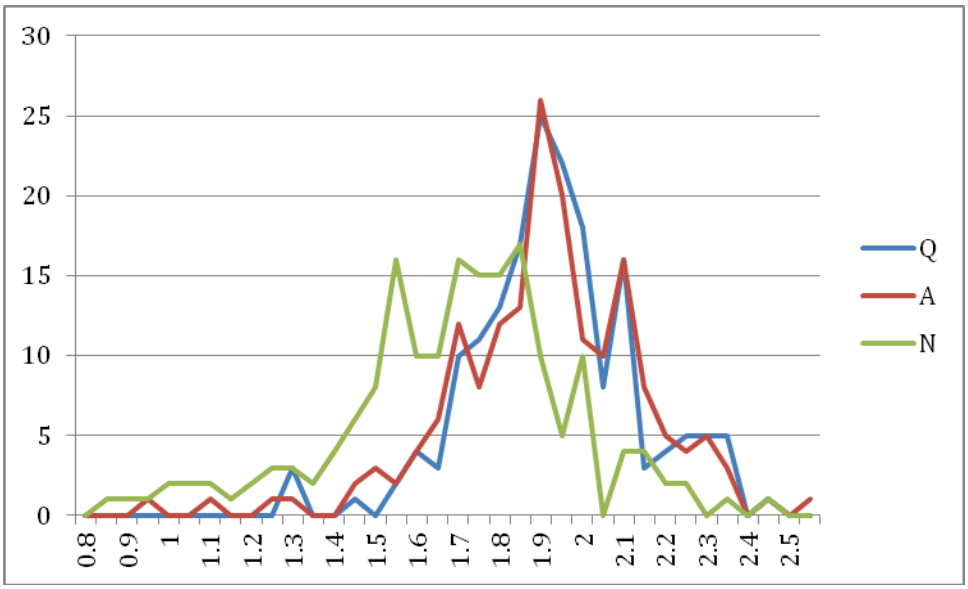


Figure 6.20: Frequency distribution of log-corrected and reading speed adjusted timing data (x-axis), by condition (A, N, Q). Frequency taken in .05 bins.

Therefore, as before an ANOVA was performed on this data which was then checked and substantiated by a series of Mann-Whitney U tests. A 3x2 ANOVA was performed on the data with Frame (Astor-framed, Quetia-Framed or Neutral) and question set (First 11, last 5) as between subject factors. A main effect was found for frame, $F(2, 762) = 50.767$, $p = .000$ and question set, $F(1, 762) = 135.029$, $p = .000$. There was no interaction detected, and the test failed Laverne's test of homogeneity.

A series of Mann Whitney U tests confirmed the findings from the ANOVA. Overall differences were found between question sets ($U = 33034$, $P = .000$, $Z = -10.642$) and also between framed and unframed data ($U = 38588$, $p = .000$, $Z = -9.298$). No differences were found between the different types of frame (A/Q) at any point so the data sets were combined for the purposes of these analyses.

Significant differences were also found between question sets for framed ($U = 11500$, $p = .000$, $Z = -10.737$) and neutral ($U = 4639$, $p = .000$, $Z = -4.372$) conditions. Similarly, differences were found between the conditions in both the first 11 ($U = 15603$, $p = .000$, $Z = -9.302$) and last 5 ($U = 4370$, $p = .000$, $Z = -4.004$) question sets.

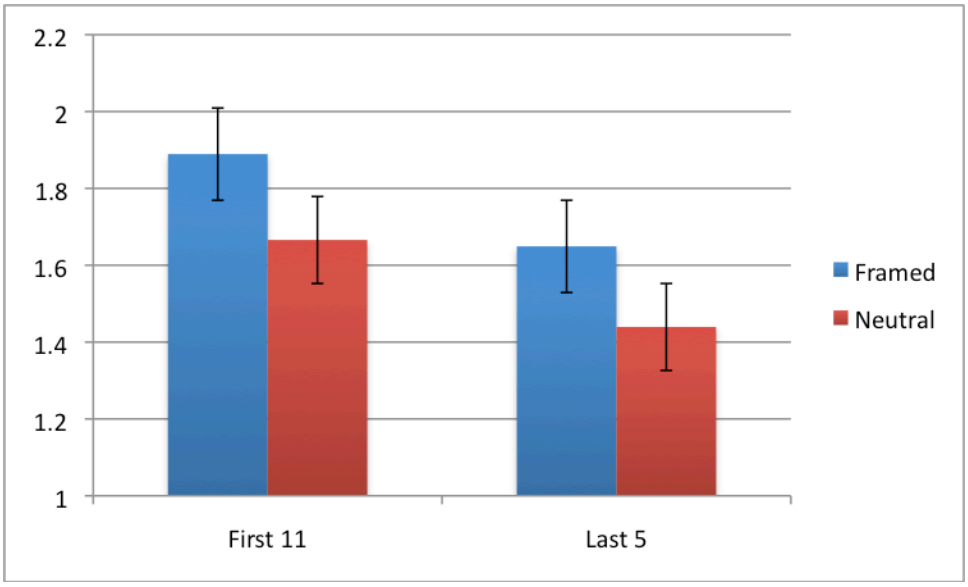


Figure 6.21: Mean log adjusted time (y-axis) by question set (x-axis) and experimental condition (Framed, Neutral). Error bars show standard error.

Eliminating questions 1-4 as acclimatizing trials, there is still a significant difference between time spent with the tweets between the first 11 and last five sections (U = 3164, p = .000, Z = -3.782). This suggests that the drop is not a statistical artifact of an initial learning curve.

This data can also be viewed by-question, as below.

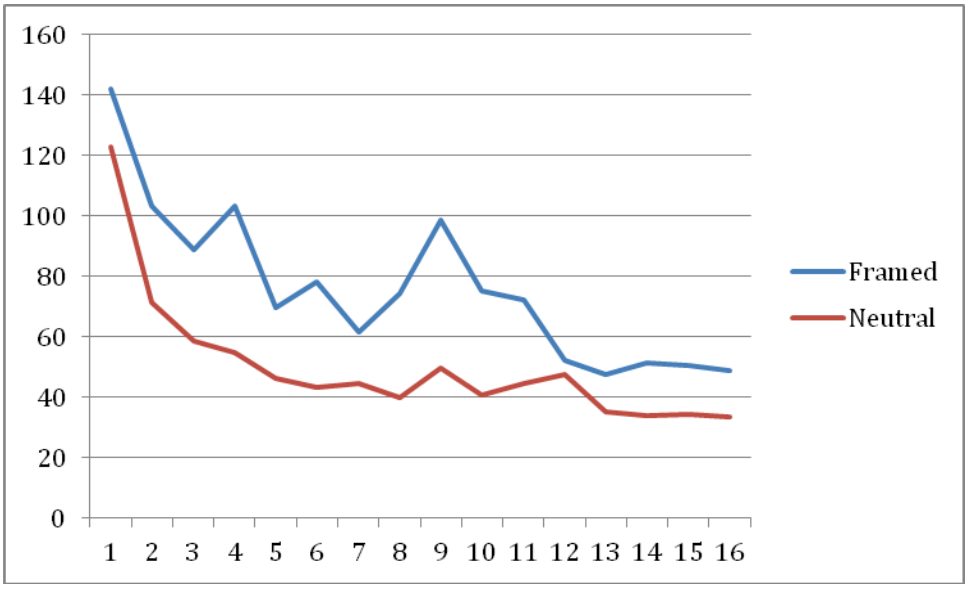


Figure 6.22: Mean (adjusted) time spent on the tweets (y-axis) for each question (x-axis), by condition (Framed, Neutral)

Effects can also be observed in the number of times that participants view the tweet section of the test.

As can be seen from Firgure 6.20 below, over the course of the experiment, participants in the framed conditions consistently return to the tweet data more than participants in the neutral condition (U = 52958, p = .000, Z = -5.302). There is no statistical difference in the two framed conditions. This difference holds true within the first 11 questions (U = 26054, p = .000, Z = -3.568) and the last five (U = 4696, p = .000, Z = -4.327). Within conditions, the framed participants do no vary between question sets, whilst the neutral participants' values fall significantly for the last five questions (U = 6032, p = .008, Z = -2.665).

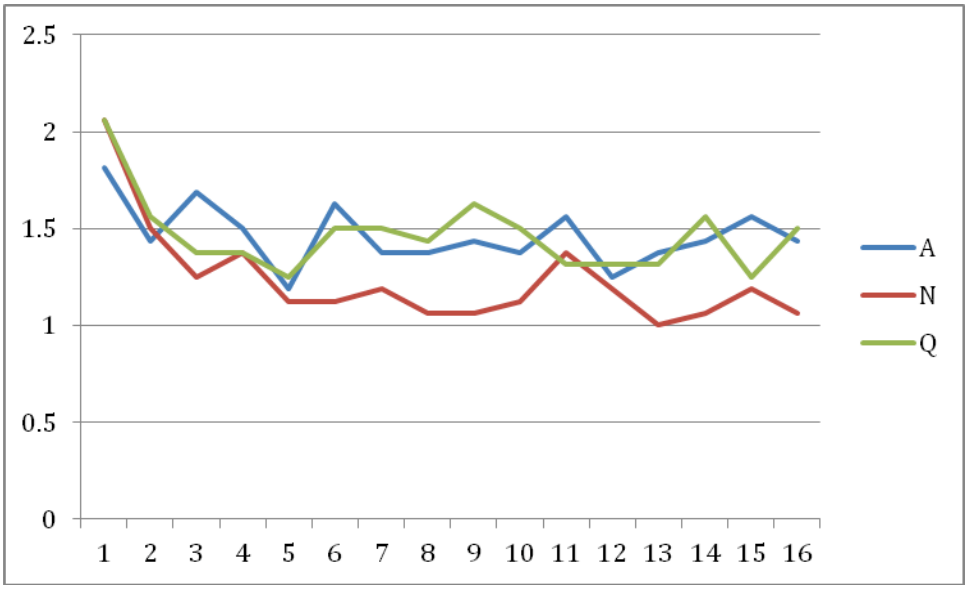


Figure 6.23: Mean number of views (y-axis) of the tweet data by question (x-axis), by condition (A/N/Q)

Rethink Data

As the last part of the experiment, participants were given two questions from the experiment to reconsider. They were told that they were being given a random question, although in actuality the questions were the same for all participants and conditions; questions 3 and 4. All information given was the same, except that there were no tweets, and thus no framing device of any sort this time around. This data was then analyzed by comparing it to the original question data. Because the data set was small, only a limited number of tests were performed.

Decisions

The choices made originally were compared with those made the second time around, as demonstrated below. No significant difference was found between the two conditions.

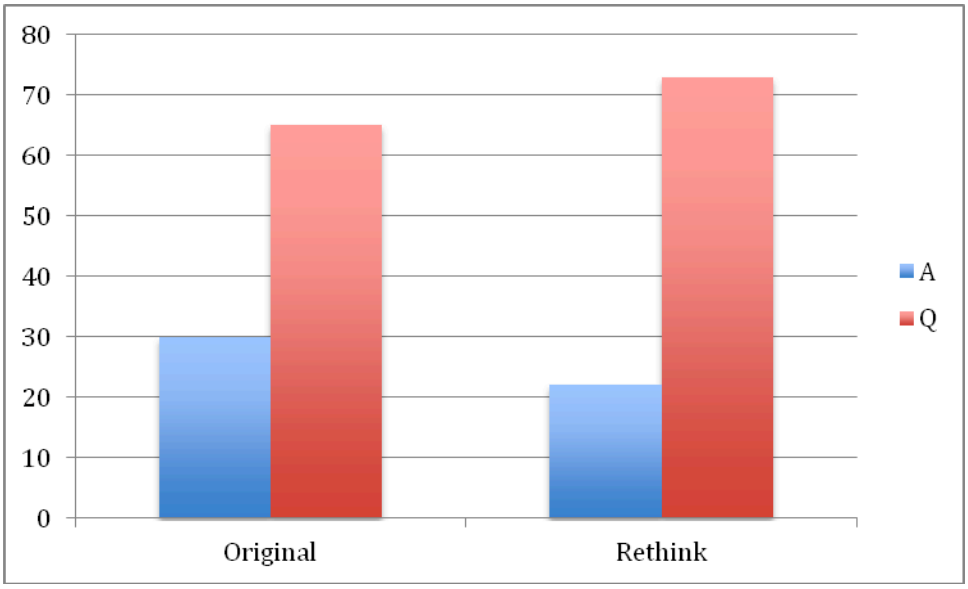


Figure 6.24: Participant Choice of Company (A/Q) (y-axis) in Original and Rethink conditions (x-axis)

The data was then split according to the framing that was used for the event that split the 11 and 5 question sections. The conditions in this case were pro Quetia (Q+) or pro Astor (A+), for original and rethink trials. There was no difference between the conditions in either the original or rethink trials. Comparing between trials, there was no difference in the A+ condition, however in the Q+ condition between original and rethink trail there was a significant difference under Fisher's Exact Test at the one tailed level (p = .048)

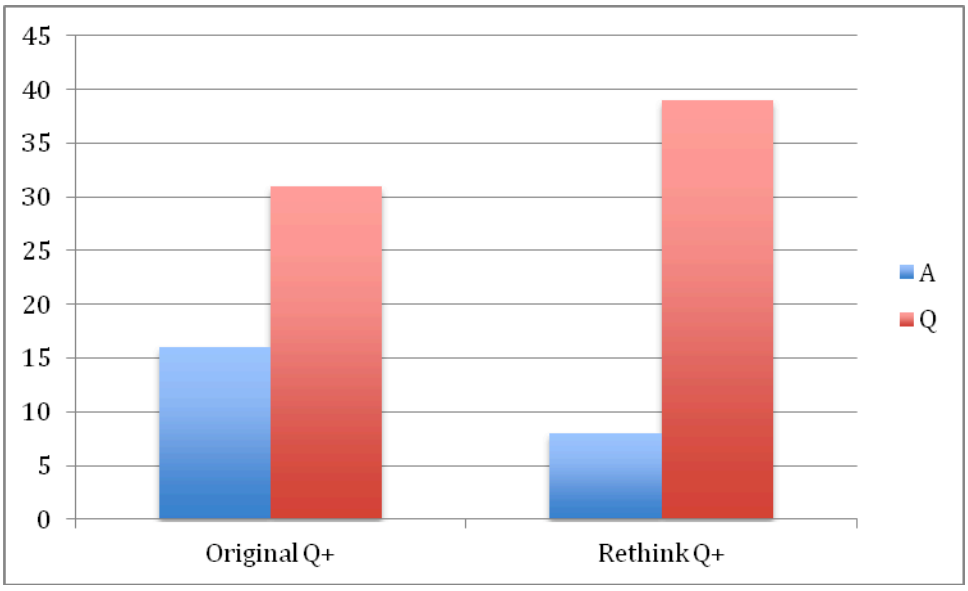


Figure 6.25: Participant choices (A/Q) (y-axis) in Q+ conditions for original and rethink trials (x-axis)

Confidence Data

Confidence Data was sorted and treated as described previously. However, no significant differences were found between groups. Confidence did not vary between original and rethink trials overall or when split by frame, question or event type. It also did not vary when participants that changed their mind were compared against those that stayed with the same choice, or within those groups between the two trials.

However, this null result does mean that participant confidence is equal to that in the original set of questions - even for the framed conditions which, as demonstrated earlier suffered a lower confidence once the frames were removed for the last five questions. This suggests that there is some permanence to the decisions as they are made in terms of belief; participants on average maintained the same level of confidence as they had before.

Timing Data

Timing data was treated as described previously, although the analysis did call for different approaches than for confidence. Time could not be directly compared between the original and rethink trials since participants at the latter point have already read the decision when it was originally presented. Even allowing for the idea that they would read it again, their performance would still be expected to be quicker simply through familiarity. Instead, analysis was performed between conditions (frame, event etc) and then these results compared between trials.

No significant differences were found for timing data relating to the choice section of the task.

The time taken to read the decision text was then analysed. A 3x1 ANOVA was performed on the data with Frame (A,N,Q) as the between subject factor. A main effect was found for frame, $F(2, 92) = 7.400$, $p = .001$. A series of Mann Whitney U tests were then performed between the individual groups, and significant

differences were found between A and Q (U = 338, p = .019, Z = -2.336) and A and N (U = 249, p = .001, Z = -3.396). This suggests that participants in the A condition were taking longer to think about their choice than the other conditions. In the original trials, no differences could be found between any of the conditions.

No significant differences were found when comparing between the A+ event and Q+ event conditions.

Extremists

In the course of conducting the study several participants commented afterwards, when asked verbally, that they felt their responses were not appropriate for the experiment. One commented that "I don't think you'll be able to use my data". Upon asking what they meant by this, this subset of participants commented that they had strong underlying views about alternative medicine and its value, and as a result did not pay much attention to any of the information that might have swayed them one way or the other. Instead their answers were made mainly based on their preexisting beliefs about the topic.

These admissions were noted when made. Their data was then examined individually, and it was found that in addition to their spontaneous self-reported bias they conformed to two other properties:

a) They were in the top or bottom 5% of recorded scores for attitudes towards alternative medicine
b) Their scores were over 80% in favour of one company for the framed portion of the test *away* from the direction that would be predicted by the frame, or in the direction of their bias in the case of the neutral condition.

No other participants met both these requirements, and combined with the self-reporting, it was considered sufficient to justify treating the group as a separate, emergent set of participants and exclude them from the main study. Of the group, two were pro-Astor biased and in Q-frame conditions, and three were pro-Quetia biased with two in a neutral condition and one in the Astor frame.

It should be made clear at this point that this was an unexpected, emergent group of participants, and as such were not counterbalanced or controlled for in any way. Some analysis was performed and is presented but should be repeated under tighter experimental control before any conclusions can be drawn.

That there was an effect at all is interesting. Participant choices in the task reflected their beliefs in alternate medicine: if they believed it was a good idea, they chose Astor. If they thought it was bad, they chose Quetia. This is despite the fact that there was no logical reason to make such a distinction, and the presence of a frame. This possibly indicates limitations to the ability of a frame to affect some people's decisions within particular topics.

The data was sorted by classing the choices made by these participants as either 'pro' or 'anti' their innate bias rather than leaving them as A and Q, since different participant's bias was in different directions. These were then scaled into a percentage amount in order to compare between the first 11 and last 5 question sets (as these sets contained different numbers of decisions to be made). No significant difference was found.

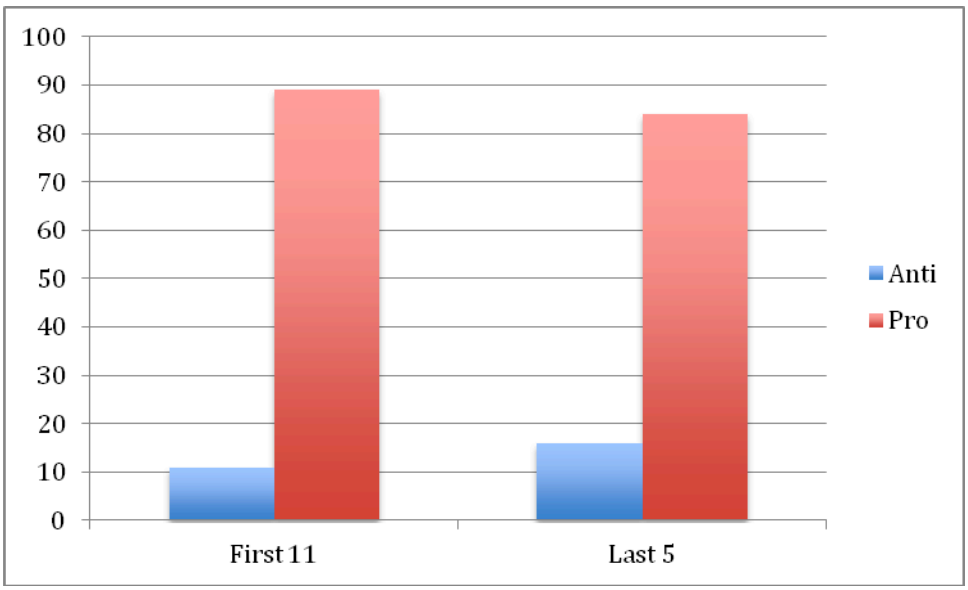


Figure 6.26: Percentage of choices (y-axis) for (pro) and against (anti) inherent beliefs in extremists for the first 11 and last 5 questions (x-axis)

Confidence was then compared to the general population, and it was found to be higher for extremists (U = 26739, Z = -1.970, p = .049). There was no difference

between question sets (U = 598.5, Z = -.963, p = .336) although this may be due to the small sample size.

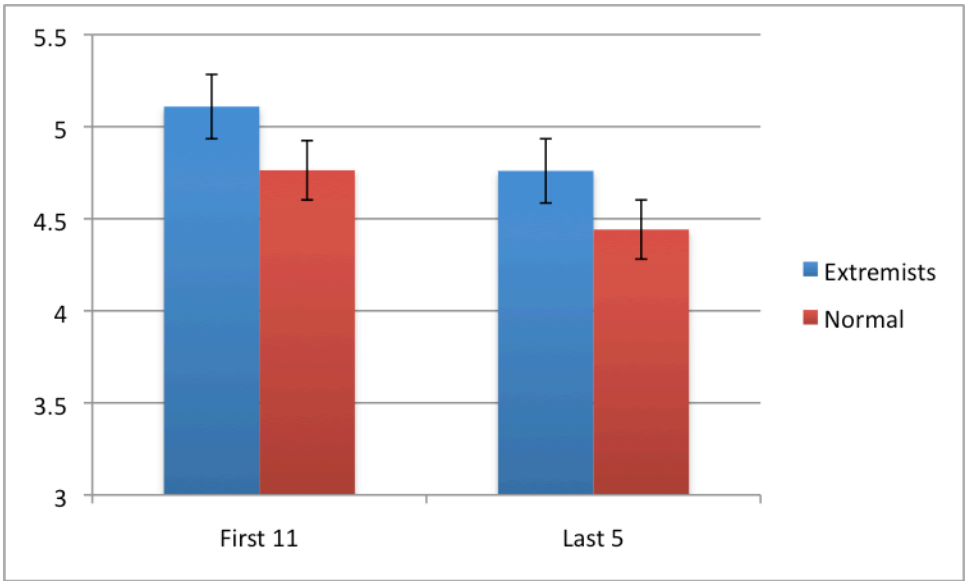


Figure 6.27: Mean confidence (y-axis) for normal participants and extremists by question sets (x-axis). Error Bars show standard error.

There are similar results for the timing data. Extremists, like normal participants take less time with the tweets over time, which can be seen both as a correlation between question number and time taken in the first 11 questions (r(55) = -.4.21, p= .001) and also when comparing the first 11 questions with the last 5 as sets (U = 308, Z = -3.939, p = .000). However, they also take significantly less time than the normal participants when comparing between both complete groups (U = 25438, Z = -2.533, p = .011). There were no differences between the normal condition and the extremists in how much time they spent with the decision text.

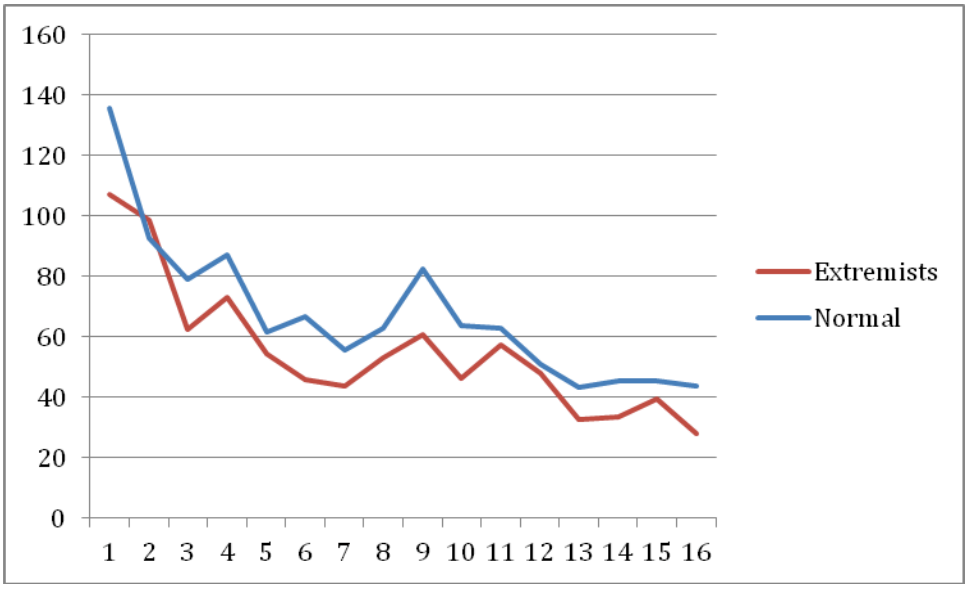


Figure 6.28: Adjusted time take to read tweets (y-axis) by Question (x-axis) for normal participants and Extremists

Within the timing data there is also some limited, non-significant indication that there may be a difference between extremists when framed or unframed in the amount of time they spend reading tweets. A small sample size and unbalanced groups mean that there are no firm conclusions to be drawn, but it appears that as in the normal groups, participants that see framing data spend longer with it than if unframed (U = 592, Z = -1.729, p = .084).

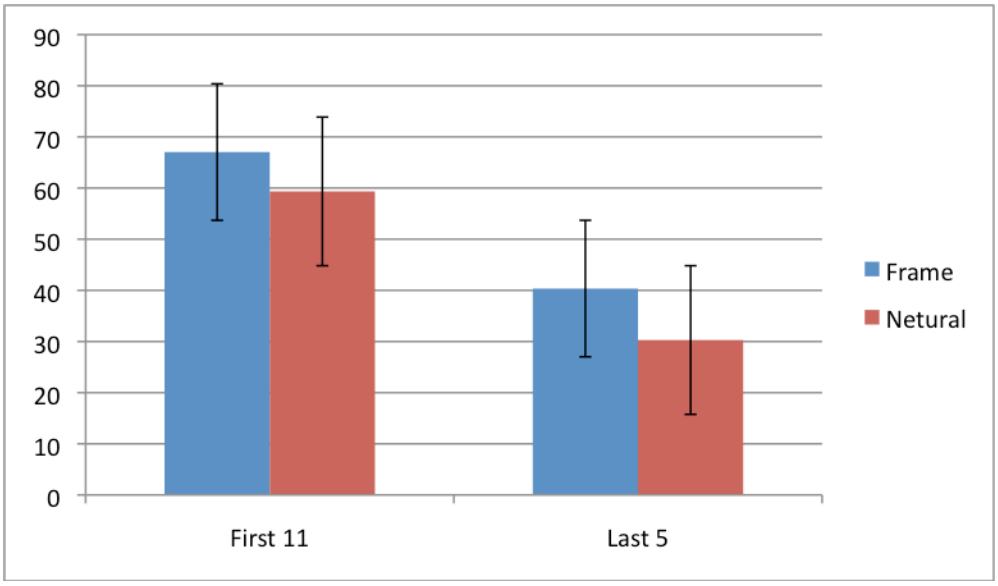


Figure 6.29: Mean adjusted time spent reading tweets (y-axis) by question set (x-axis) for framed and neutral extremists. Error bars show standard error.

The nature of this data set is that, as noted, it is incomplete, uncontrolled and potentially unreliable. Certainly it will not be use as the basis for any in-depth analysis for these reasons. There are indicators that this could form the basis for future research.

Discussion

Approach

As evident from the previous section, this experiment generated a large amount of parsable data, with the associated large number of permutations that can be considered. Richness and multidimensionality was something that was intentionally pursued for this experiment in the belief that cross-modal assessment is fundamentally more reliable than single-measure for this sort of study. As this section will hopefully bear out, this approach has largely been justified as multiple sources can be seen to corroborate each other when identifying larger abstract-level overall trends. When investigating something relatively unmapped and not yet understood such as this topic, the benefits of and reasons for this approach should be self-evident.

However, this approach is not without its problems. Data overload is one example of this, and the difficultly in identifying clear results in a sea of data. Type one errors are another; the greater the number of analyses performed the greater the chance that at least one test is a false positive rises. In this analysis it is almost a statistically inevitability that one such result exists within the data presented due to the sheer number of tests performed. This section will therefore attempt to address these two issues by not generally focusing on individual results, and rather be concerned with drawing out the overall trends and larger implications that can be seen from multiple measures. This should serve to clarify any potential data overload, and to not place undue significance on any one finding, avoiding drawing conclusions from a single false positive.

Hypothesis Testing

Before addressing the specific hypothesis stated earlier, it is worth addressing the implicit hypothesis of the thesis as a whole. Specifically, this experiment

provides further evidence that framing effects both exist within a task-based environment and have unique properties that make them an interesting specific case to be considered, and that strategic adaptation can be driven by context. It is believed at this point that these principles have been established beyond a reasonable doubt.

The first hypothesis stated that framing would still be observed with the new approach. The data from the experiment upheld this expectation. Despite changing the type of frame employed (opinion rather than statistical), the positioning of the frame (separate rather than integrated), and the level of ambiguity and ethological validity (a twitter feed containing differing opinions) framing was shown to continue to be present in the same manner as previously seen – manifesting as deviating from the 'neutral' baseline by a broadly consistent amount in the direction of the frame presented. Additionally confidence was also seen to vary with these factors as before – again suggesting that this is a broader cognitive phenomena than being constrained to a particular frame presentation. There remain broader issues to address in the area of ecological validity, and it is true that this experiment used the same basic paradigm as the previous one so there is doubtlessly further work to be done moving beyond that constraint. But the varying the most important aspects – the type of framing and positioning of it – have produced broadly the same results.

The second hypothesis stated that framing would continue to be seen once it was removed part way through the experiment. This was also supported. The importance of these results relate directly to the previous chapter's results where Over-Framed participants did not show framing in the way that the Question-Framed participants did, and also how in the card game task framing was shown to exist as a direct result of framing that occurred at the beginning of the task. These results support the overall hypothesis that these results can be explained by integration, or a lack thereof, of the frame.

These results have shown that framing can have a persistent effect in this sort of paradigm once the direct frame has been removed, so the lack of framing in the previous experiment is less likely to be a methodological quirk, and more likely

to be the frame going un-integrated. Because it was presented in the instructions it was never actually made relevant to the task in the way that the other, effective frames were (including the instructions in the card game, which were task-based as opposed to scene-setting). This supports the idea that one of the most important parts of framing is presentation of the frame in such a way that it is not *only* attended to, but also seen in a way that is relevant to the task decision being considered, and ties into the importance of the model's integration stage. Additionally, it appears that the actual impact of framing is initially noisy for both this experiment and the previous one, suggesting that it may take time and repetition for this integration to occur. Finally, the actual effects of the frame once removed were significantly weaker and less pronounced than in the first eleven questions. This can be at least partially explained by the experimental construction, but also implies that any framing will be weaker when not directly reinforced. So this also supports the prior suggestion from the previous chapter that the introduction of the frame did have an effect, but that it was more to cause confusion and uncertainty than systematically affect the decision made.

The third hypothesis predicted that confidence and other measures would be affected by framing as seen in the previous experiment, with framed participants being more confident than unframed. This was supported by the data. The complicated interactions will be explored in detail later, but the general expectation that framing would affect things other than just which choice was made when making a decision was born out. Confidence was also seen to be affected by the removal of the frame, and by whether a participant went with or against the frame. This has significant implications for framing effects in dynamic and complex environments where multiple factors such as this will be at play.

The fourth hypothesis stated that the mid-experiment frame would be expected to frame future decisions from that point. This was not supported by the data. This finding does, however, actually tie into the previous observations. Again, it can be argued that the issue here is integration of the frame, although in this case relative integration. Information was provided and framed, but participants did not integrate it into their understanding or decision making process. This was

true even in the neutral condition which had until this point been exposed to no framing, so it is not simply a case of one frame overruling another.

The implication is that the information was not seen as important for basing a decision upon, or more to the point that participants already *had* the information that they would be making a decision about it with. At that point all participants had been exposed to a great deal of information, framed or otherwise, about the situation. This frame simply was not significant enough to guide a decision one way or the other, something that must be attributed to the context it was in, since the actual framing was modeled on the Asian flu example that is known to be effective in this manner. So prior experience is going to be relevant in frame impact, and sufficient experience can mean that a frame is ineffective. Again this speaks to the importance of integration. This result is complicated by the apparent retrospective framing seen in the rethink questions, however. It should be noted that this was a single, relatively small result that needs to be investigated further, although it does suggest one intriguing possibility: it may be possible to retroactively frame how people feel about the decisions that they have already made.

If there was a single, overriding conclusion to be drawn from these results, it would be that framing is *complicated.* Admittedly this is something of a truism – the sheer amount of research and work put into the field is testament to the fact that this is already appreciated, but it bears further consideration. Research has generally been concerned with identifying the factors that can be framed, what different sorts of framing there are, and how these can be manipulated. None of this is simple, but what this data illustrates is that even what has previously been understood is not the extent of the complexity of the area. Even when participants may go unframed, when there is no significant difference in the type of choice made as a result of exposure to a frame, participants can still be affected by frames – in their confidence, in the amount of time they take with a task and (it must be presumed) in other dimensions that this experiment did not measure.

Broader Themes

Having addressed some specific questions, this experiment also raises a number of larger issues. The results of this experiment actually go beyond specific findings; what is notable is the fact that different measures corroborate each other. These speak to larger, broader themes that can be drawn from the work. Broadly speaking these themes are: Social Media as a framing device, Framing Effects *beyond* decisions and Framing Effect Persistence.

Social Media as a Framing Device

As noted above, the main hypothesis of this experiment was not disproven: participants were framed by the used of social media in an ongoing task-based environment. This framing was consistent, did not decay with feedback, and only lessened when removed.

Superficially it might appear that these results show nothing more than things that have been demonstrated with advertising over the last sixty years or so: that people's decisions can be influenced by the right information. But to draw that conclusion would be to miss what is specific about frames and particularly applicable to social media. Frames are not consciously understood to be biasing; they are internalized and rationalized to be the actor's own logical decision – something that even the most sophisticated adverts do not generally achieve. At their best, people are still consciously aware that someone is trying to influence them from the nature of the interaction with an advert. Additionally, this content and the manner in which it is generated is 'crowdsourced' and organic rather than centralized and directed, as is the case with advertising. Frames are not simply opinions or information, but often perspectives, interpretations and philosophies. This research illustrates things about the how community-generated opinions can affect decision making and spur behaviours.

These results, particularly the evidence of *persisting* altered opinions over the course of the task suggest that we can start to understand some of the previously cited real-world examples of activity. A conventional model of initiating such behaviour would rely upon central coordination, but the above results suggest that due to new technology, users can now spontaneously generate such

behaviour. It is not hard to see the London riots in this light, where messages spread on the BBM network have been suggested to play a large role in organizing the disruptions. A question that has repeatedly been asked is 'why did people act like this' and this research suggests that the answer lies, at least partially, in framing of the decisions. The effect might be small – as the latter removed-frame questions suggested – but it would only take a small percentage of the thousands that saw the messages to swell numbers over the tipping point beyond which the behaviour becomes self-perpetuating. We already know from other sources of research that people think differently in a group to their actions as individuals, and that the compulsion to 'go with the group' is a real psychological effect (Esser, 1998). Framed messages of this manner could be easily seen as creating a 'group' dynamic for decisions, and once enough people had made the choice to participant that effect would only snowball with the visible evidence of others taking part. In many ways it is similar to more conventional political movements, where 'momentum' is seen as key. In 2008, Barack Obama was not the front runner for the Democratic nomination for president, but early victories in particularly Iowa pushed the narrative that he was a real contender, at which more and more people decided to start donating and volunteering for his campaign (as can be seen in the publically reported FEC filings for when donations spiked). It is not hard to see from this how slight alterations in behaviour choices due to social media frames could potentially have very real consequences.

Knowing that social media can be framing should be an important factor in understanding patterns of influence and effect within these networks. This work suggests that purely logical information and connections are insufficient in understanding these interactions. Semantic search for keywords, for instance, says nothing about the context in which those words are used. Moreover, framing – which as demonstrated can affect planning and decision making let alone opinion formation – is all about context. A glass being half full / half empty is an obviously framed statement, but simply checking for 'glass' as a trend would either miss the use in which it is being applied, or the other side of the argument. Similarly, a story can be widely reported, but the manner in which it is

reported to people will be of as much importance as the informative content that it possesses. Indeed, since one of the limitations of twitter is the 140 character limit that precludes long posts, this becomes even more relevant. Although links to longer articles are widely used on the site, there is no guarantee that people will actually click on these. People who are following the feed will see the tweet however, and perhaps most significantly, people that do not care to click on a further link would *only* be exposed to the frame, whilst also implicitly picking up that the interpretation is backed up by well sourced material.

Having observed that social media both can be framing, and also presents numerous structural and cultural characteristics for enabling that to occur, a question arises of the potentially more ethical nature; one of it being used for control or influence. Framing can not only influence people to make a particular choices, but will do so in ways where the people framed then post-hoc rationalize it as both rationally based and self-motivated – the potential for abuse is self-evident. On pausing to consider this however, it becomes apparent that whilst the *potential* is there, there are also significant structural barriers to it being actually used in such a manner.

People on social media sites choose whom they talk to and what they follow: they can control their viewing habits. Attempts to force people to pay attention to something that they do not want to in those situations often comes across as forced and thus rejected rather than willingly engaged with. Since one of the prerequisites of framing is that participants do not see the frame as being biased or slanted this is an obvious challenge to blunt attempts at persuasion. Twitter's use of 'promoted' trending topics for advertising revenue illustrates this: users do generally engage with the topic, but not always in a flattering or beneficial light. Heavy-handed attempts to frame a situation or information will be exposed to the same issues.

Additionally, the setup in this experiment actually demonstrated that singular examples of a particular frame do not stop decisions being pulled in the opposite direction via the weight of opinion. The 'counter' tweet framing in the opposite direction was present in all questions, but framing still occurred regardless. If a

singular piece of framing were attempted towards a particular end, the data here suggests that this would not be sufficient to alter behaviour if other opinions were also present. Framed information would have to be planted on a larger scale from multiple sources, a problem that then overlaps with the issue of user control. Getting people to follow enough sources that were producing enough consistent information in order to created significant influence would be difficult. This may go some way to explaining some of the trouble that authoritarian regimes have in controlling social media in the same way that they do traditional outlets, as has been seen in the aforementioned 'Arab Spring'. Because of the lack of centralized control and primacy of user-directed attention, understanding the role of framing in social media may be more effective for tracking and forecasting than for influencing.

Contrarily, however, it does suggest that there is the potential for single, influential, and trusted users to be powerful frame drivers. Popular twitter users can amass hundreds of thousands (or even millions) of followers, and their activity can already be seen to shape opinion. Sometimes known as the 'twitterati', an example is comedian and actor Stephen Fry whose tweets have been associated with the failure of the BlackBerry Storm as a handset in the UK(Cellan-Jones, 2008). On a more regular level, it is common to observe celebrity mentions engendering the adoption of particular 'hashtags' or creating trending topics as a result of their tweets. Combining this research with an understanding of the significant people on twitter (or another social networking site) through node theory and you could possibly generate the illusion of an 'organic' online reaction sufficient to act as a frame.

The confidence data gives some more insight into how this experiment's findings may apply in the real world. This experiment employed a forced-choice dichotomy, but generally in everyday life it is common for choices to have multiple options, even if many of them go unused or unconsidered. If nothing else, most choices have at least the third option of simply doing nothing at all. The confidence data can give us an indication of how participants felt about their choices beyond the option they chose, implying how likely they might be to

actually do that thing, what level of effort they might put into it or their general attitude if faced with that problem.

Firstly it seems clear that context is key. Individual questions produced polar-opposite trends in confidence both across all participants and comparing between conditions, suggesting that whilst the behaviour that may be primed by social media, implementation will vary with what is being asked, when and why. This serves as a reminder that we are still discussing affecting 'real choices' – where people feel they have a real decision to be made. Framing and other factors will not be as potent if the decision is clearly lopsided or the participant has strong preexisting beliefs, as the data from the extremists showed us. Of course, important decisions are invariably those that are difficult because there are multiple viable options, so this should not be taken as suggesting that this data is of limited value.

Confidence data gives us some idea of how likely people are to pursue the choices they make in this experiment. For instance, it seems that if a person is framed in a particular way, they will lose confidence in their decisions when this frame is removed – even if the consensus 'good choice' is still the one they were previously pursuing. More broadly however, this suggests that frames are important even if people *seem* unaffected. Between the A-frame and Neutral conditions in the last 5 (unframed) questions there is no significant difference in the choices made – but there *is* a significant one in confidence. The frame is affecting a participant beyond the actual choice observed - participant *attitudes* have been affected. This implies that frames from social networks could have an impact on actions in ways that are not necessarily measured by simply monitoring choices made, and that the importance of framing may exist in the shifting of these attitudes whilst no visible difference is being made to actual behaviour initially. Long before actions are actually taken, online framing could change moods, shift perceptions and set the groundwork for the point at which actual behaviours alter – an idea reflected in the volatility of the confidence. Where otherwise confidence was relatively smooth, if framed it became significantly more variable. The behaviour seen in the examples discussed reflect this - in both cases, passions were suddenly ignited unexpectedly, and have

generally left commentators wondering why and how this could suddenly occur. The confidence data here does not directly speak to all the potential causes of these, but it does indicate that frames interacting with decisions raise the possibility of these unexpectedly rapid shifts in opinion and confidence, which would seem to be a characteristic of these grassroots, decentralized movements.

A final factor that should be considered with all these observations is how the data shows a lasting effect, for both frame and confidence, *after* the frame had been removed. These effects are not simply conditional on proximate exposure. It cannot be assumed that simply because a person or group is not engaging with social media at that time means that they will be unaffected by it. Even the act of having been removed could be a significant factor – see the drop in confidence when the frame was taken away in the experiment. Add to this the growing modern pervasiveness of social media in general, and the potential for simple access to this information to drive, change and generate behaviour is clear.

Framing Effects Beyond Decisions

As the final point from the previous section touched upon, one of the most significant effects to be observed in this study was confirmation of the previously observed effect that framing can have on non-decision factors. That is that where research into framing effects has naturally centered on the way that they can sway a decision in a particular direction, this series of studies has illustrated that this is not the limit of the impact they have on participants.

This can be seen in several data sources for this study. Firstly, as has already been noted, confidence was affected according to being framed or unframed. Effects could be seen between frames according to whether choices were supported or opposed by the frame in the first 11 questions, so there is some evidence that this is about directional effects, but at the same time a uniform effect could be seen between framed and neutral participants in the last 5 questions. In other words, framing itself – the simple act of framing regardless of the direction or other factors – can impact a participant's confidence.

Confidence is a particularly relevant metric to consider in this sort of experimental setup and theoretical question. As an example of why, consider an

imaginary gorge, spanned by a rickety rope ladder of the sort seen in pulp adventures such as 'Indiana Jones'. In our example, both Indy and his companion for this adventure choose to cross the bridge, but they do not share the same amount of confidence about their Endeavour. Where Indy strides confidently across, his companion has doubts and proceeds a great deal slower. Clearly, in this example, both people have made the decision – to cross the span using the rope bridge – but their different levels of confidence mean that they approach the same problem in a different manner. Similarly, a hypothetical soldier operating in a warzone, may be told to check a series of buildings for enemy combatants. Intelligence informs him that this area has not (unlike many areas) been seeded with landmines. Whether he believes that intelligence or not will clearly affect how his approaches the sweep of the buildings, and the dangers he prioritizes being aware of. The same *decision* is made, in both cases. But the *manner* in which that decision is implemented varies according to *confidence*.

This becomes doubly important when we remember that variance can be seen in confidence levels when there is no difference in the decision being made. Both in the last five questions, but also in the question-by-question data from the first 11 questions where decisions were still being framed, there is significant variance in confidence compared to if the data is unframed. So whether a participant is framed or not becomes in some ways irrelevant – their cognitive processing will have been affected by the very fact that some of their data was framed and even making the same choices they are likely to respond differently to an unframed participant.

And this effect is not limited to confidence. Similarly, effects can be seen in the difference between the time taken in reading the decision text. Here, participants are reacting differently to identical text, as a result of having been framed, and participants also return to framed information more having read it once. The result here is that the act of framing something can be seen to affect the way in which an act is carried out: more time is dedicated to thinking about the problem, the time spent on different sections of the task is different and differently distributed as a percentage of the entire time. Again, this provides more supporting evidence to the argument that frames have an impact beyond

the decision itself. If the only place that the effect was seen was in the confidence measure it might be possible to argue that it was an artifact of that single measure. Evidence of a broader tendency however would seem to disprove that theory. Evidence of different timing patterns seen in otherwise identical text suggests that framing is affecting the way in which the task is being organized and attention prioritized. There seems to be evidence of different structural approaches to the task as a result of framing - and one that persists after the frame is removed.

It is possible that people could be presented with framed information and still make the same choice that they would have in an unframed scenario. Obviously, we cannot identify what these choices would be – by definition we cannot observe both a participant's framed and unframed choices. However, the fact the framing did not result in a 100% choice favouring one or the other direction, it is logical to suggest that there are some decisions that were unaffected by the framing. It is to be expected that this could be true for a real-world task as well. However, the evidence presented here suggests that on some level it *does not matter* if the actual decision is affected by the framing. The simple act of having been framed will affect people's performance in a task in other ways. On a purely cognitive level, decision making can take longer even though the decision made does not change.

This experiment demonstrates, essentially, that framing can have an effect on *process* as well as *outcome.* And there are a number of tasks that rely on this process, and will be affected by it if a task is framed. Any task where speed and quick decision making are important for instance. Indeed, it should be remembered that framing is not an either/or proposition in the sense that it is either there or now. All information is framed to one degree or the other; even 'neutral' information is distinguished by its lack of frame and actually quite a difficult state to achieve. A majority of the information we encounter and share with other people will be framed by its and our very nature. Humans tend to impart information with qualifiers and secondary information at the same time, informed by our opinion of a given topic.

Consequently the implications of this experiment are not so simple as to be dealt with as-and-when framing is present; most interactions will involve framed information in some capacity. What this evidence suggests is that there are a multitude of situations where it could be beneficial to design for the effects that framing will be known to have on tasks being performed. It could be used to not simply enhance decision making or lead in a particular direction, but to guide the methodology employed in implementation of plans also.

Framing Effect Persistence

One of the recurring observations that this thesis has made is to do with the permanence of framing beyond a single question, and this experiment provides further evidence for that. Previous research has generally assumed the question of framing relates directly to what is being framed – indeed, most of the classic demonstrations of framing concern single decision paradigms that, by definition, cease to continue once a decision is given.

This experiment demonstrates that that view is insufficient to account for the impact of decision framing. That multiple aspects of cognitive processing beyond just the decision can be affected has already been discussed, but additionally participants continue to be influenced in the decisions that they make once the frame is removed. Confidence is affected as a direct result of having been previously framed, decisions take longer, sources of framed data are regarded longer and more frequently. All of these result point, in different ways, to the same conclusion: that framing effects do not stop at a metaphorical 'water's edge' of a question they relate to.

This is not surprising to some degree, but it is nevertheless significant because of the consistency and width of the effects that can be observed. Firstly, prior framing affects future related decisions. Whilst somewhat expected, this it worth making particular note of because it establishes that the frame information is being integrated into a larger overall mental model of a problem. Rather than being context-specific and non-transferable (as might have been assumed) it seems that it is being established as relevant general knowledge and context. In other words, the frame is affecting how the information it concerns is

understood and encoded for future use. Given that frames are understood to generally be undetected by the people that are being framed, this suggests that long-term understanding can be affected by framing.

Again, this is somewhat as would be expected. The nature of information and learning is such that it would be surprising if people did not integrate understanding based on the way that they had experienced it. Regardless though, this provides evidence that framing is a factor for both the encoding and understanding of information, and also that it matters in a task based environment. Framing something for one instance will affect future decisions made about that same factor.

However, some caution is due here too. Whilst there *were* differences to support that hypothesis, they were small differences. The general trend of the decisions made was towards Quetia regardless of how the questions were framed (or not framed) up to that point. Frames should not be seen as being super ordinate to context and other tendencies. Indeed, the question-by-question analysis of the first 11 question choices shows that frames were not setting the direction that a given choice went in, but rather stretching the general pattern that already existed in that direction. This same principle – guiding but not defining – can be seen in the small-but-significant differences of the last five questions.

Regardless; these small but subtle differences continue to exist. As a result of framing, future choices are affected, as is confidence and time spent on different sections of the experiment. Frames may be a case of subtle guidance rather than mass conversion, but in some ways that makes the discovery more significant. Again, frames are generally internalized as being a person's own choice and opinion once followed, and they do not rely upon a logical argument to persuade. This means that people exposed to framing of a particular direction will continue to be inclined towards that direction, but more due to *feeling* something rather than *thinking* it. And this may well make their opinions harder to move in the future. It can be relatively easy to logically disprove a false assumption, but much harder to dispute something felt 'from the gut'. This, after all, is the reason why people have superstitions and folk theories. An example of something that is

widely believed but actually untrue is the theory of 'hot hands' in basketball, where a player who sinks a three pointer (a long range and relatively difficult shot) is thought to be more likely to do so in the future. Statistical analysis has shown that this widely held opinion is actually false – but it is still widely held.

That framing affects the likelihood to choose something and the idea that it 'feels right' rather than a logical reason for picking it actually implies that it may be a more useful form of persuasion and opinion setting. Whilst its effects may well be small, when integrated they are also persistent due to personal integration and opinion, potentially at least. Obviously this particular property of framing effects seems likely, but definitely requires further investigation. Having established that framing persists as a factor affecting many things beyond the question itself, many such questions present themselves for future investigation.

CHAPTER SEVEN – Adaptation and Frames in Tasks: Discussion And Speculation

The driving concern behind this thesis right from the start has been attempting to better understand how people make decisions, and specifically how they utilise context whilst doing that. As with most research of this nature, the search for answers has opened new questions and expanded both understanding of the answer, and also the problem space as it progressed. Real progress has been seen in both understanding how decision making is guided by context, and where the limits of bounded rationality as a means of explaining this behaviour exist. The intent of this chapter is to draw together the various related strands of this understanding into a cohesive whole.

Firstly, there will be a brief recap of the context, issues and motivation for this research, so that the work can be better considered as a whole. The model that was originally proposed in chapter three will then be re-introduced and its usefulness discussed. The main themes from the research will be presented as extensions to the concepts of Integration and Formulation.

From here, the implications for bounded rationality and framing will be considered and a theory of bounded rationality in tasks presented. Implications and applications for this theory and the work as a whole will then be considered before concluding with some suggestions for potential future work.

Introduction

This thesis has been concerned with how people make decisions. Primarily it has been focused on how context affects decision and can influence choice. For that the concept of bounded rationality was used to model systematic variations in information that did not vary logically. In this way, the thesis has used the two related properties to examine each other. By placing bounded rationality in the domain of task performance, its limits have been evaluated and new findings made. Conversely, studying how decision making relies upon context has utilised

the framework of bounded rationality. The two related concepts have been used to expand and better understand each other.

This process has inevitably involved the narrowing of scope and carefully controlled experiments. This focusing of scope should not be taken to lessen the breadth of the findings, however. The results are consistent with identifying abstract properties that should remain true through varied input and circumstance. What this chapter seeks to do is to explore how the two related understandings have been expanded, and to present that understanding as a whole. It should be noted, however, that the questions being asked were inevitably interconnected. So better understanding of the model of adaptation comes with some understanding of the role of bounded rationality within that, and vice versa for the understanding of bounded rationality. The two are interrelated concepts and it would be a mistake to try to see them as being entirely separate. After all, we are animals that are rational within our boundaries, adapting to the constraints of a task.

Approach

In the course of this investigation, a wealth of data and findings were gathered, which provides some problems in terms of understanding the data as a whole and drawing cohesive findings from it.

When such a large amount of data is produced, the danger of making a type one error (false positive) is particularly high for at least one result Most of the tests used in this thesis had a confidence baseline of .05. Therefore, one in twenty tests would in theory be down to chance – and there were more than twenty analyses done. That said, many of the results reported far lower confidence thresholds, and cross-analysis within a given experiment should already have theoretically lowered the chance of that error being committed. Additionally, the purpose of this section is to draw the experiments together and identify the general trends and consistent observations that run throughout it, further lessening the chance that type one errors could be influencing the conclusions being drawn here.

A consequence of this approach is that some particular results seen elsewhere in the thesis will not be mentioned in this section. Some of these are possibly artifacts of the particular circumstances in which they were generated. Others potentially represent more generally applicable findings, but require additional research before they can be attributed to these underlying phenomena. Regardless, their omission should not be seen as a rejection of that work, but simply that further work is needed to investigate them.

The Model of Adaptation

Overall, there were two main themes that emerged from this work; evidence for how information was processed in the first place, and then how that information was used to come to a decision. These observations matched up neatly with the Integration and Formulation stages found in the original model detailed above, although it should be stressed at this point that this connection was noted *after* the trends had been identified – this was not a case of confirmation bias at work. The following section will detail the expanded understanding of these two processes.

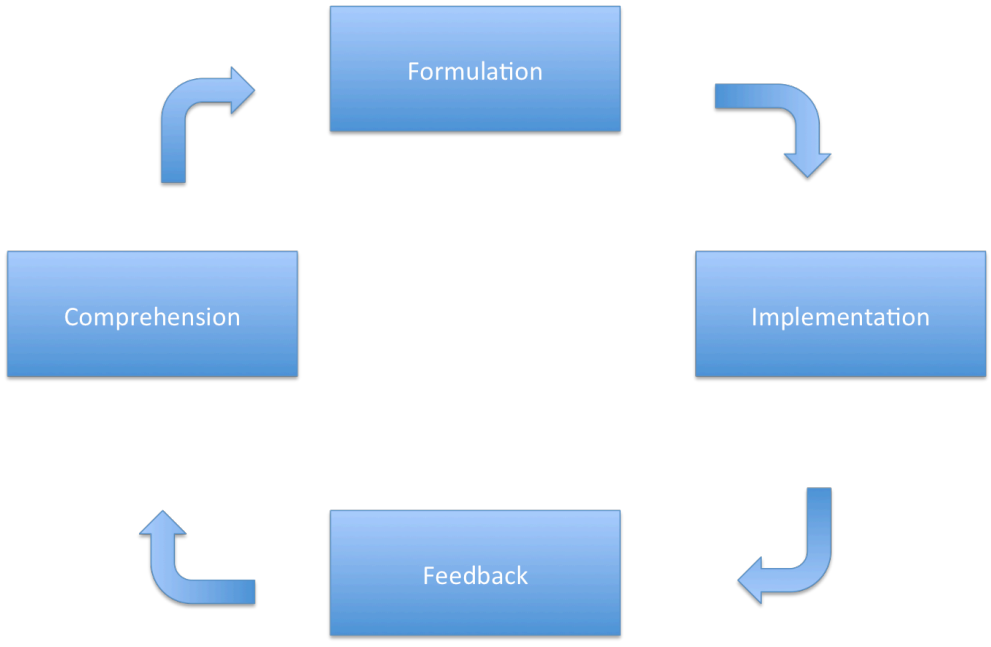


Figure 8.1: A general model of cognitive adaptation to a novel problem

Through this thesis, the general pattern of results has been to support the initial hypothesis developed in the preliminary study about modelling adaption. The basic stages that were suggested have largely held up to scrutiny in providing a basic accounting of performance. The results that were seen could be explained in terms of those stages, and it provided a useful framework to separate between the different parts of processing when reasoning in a task.

What the model does particularly well is to provide a framework upon which the effects of framing can be studied. It helps to separate out the components of the process, and to draw out the complexities that emerge. Whilst the four initial stages remain useful (perhaps unsurprisingly, since it was intentionally broad) the detail of knowledge in those sections has at the same time increased greatly. It is this that will be examined in the next section, particularly for the sections of formulation and integration.

Before that, however, two points of criticism should be noted. Firstly, there will be no attempt to move beyond the basic model established in chapter three – beyond the deepened understanding of the stages detailed below. This is intentional. The thrust of the research in this thesis was not intended for a specific, cognitive processing level of cognition, and the data that does exist to enable that sort of reasoning is not comprehensive enough to justify a specific retooling. It is believed from the data that the above is certainly an over-simplification, but further research is needed to identify exactly how the modules interact, or might be more correctly constructed. There is also a wealth of additional cognitive research that has already been done, which could serve to aid that process, which falls at least a little outside the current scope of this work. It is envisioned that future research would be able to re-apply this general understanding into more specific modelling criteria.

Secondly, no expansion will be made of two of the stages: feedback and implementation. That is not to say that they are not important, but simply that this thesis did not provide enough information to justify a broad rethink of these general categories. Indeed, much research already exists for the questions that could expand these areas: signal detection theory with framing, and motor

control theories in implementation to name two. It was simply decided to restrict the focus of this work to the stages that the evidence from this thesis says the most about. Again, it is anticipated that future research and input from other disciplines could help to expand those better than this thesis usefully could.

Integration

The first consistently observable factor to emerge from the studies was the importance and unanticipated complexity of integration. Integration as it was initially envisioned in this thesis referred to the process of discrimination that occurs between perception and processing, determining what perceivable information is then made available to be processed. It was seen as a cognitive mechanism for taking the amount of information that is available in the world and filtering it down to that which is used for decision making. It is apparent from common experience that people are capable of missing things that are right in front of their eyes: to somehow miss that pen they're looking for even as it rests on the desk in front of them, or the classic example of searching fruitlessly for a pair of glasses that are already being worn. Integration would be the stage at which this occurs where the perceived information is encoded and passed on (or not).

That this stage would be important sounds like simple confirmation of that which would be expected from common intuition; in order to have an effect information must by definition be understood in the first place. However what was anticipated was that this process was neutral, systematic and objective, at least in regards to semantic information. Since the systematic differences in this set of studies were primarily at the conceptual rather than perceptual level it was believed that this would have no effect on the process of integration. Consistent evidence, however, points to the idea that integration extended beyond this simplistic representation and necessitates a rethinking of the process.

Experimental Evidence

The first evidence that integration was important for more than simple discrimination was seen in the card game experiment where different strategies were applied to elements of gameplay. Selective application of the frame between different card types (normal and power) was observed, which was interesting on its own merits but for the purposes of this section demonstrates the effect of integration having occurred and then a frame applied differently according to understanding of the task. Additionally, however, there was no effect seen in how cards were discarded. Discarding was an appropriate place for framing to occur, and additionally a learning effect occurred moving play towards optimal use, so it could not be said to be simply beyond understanding or too obtuse. Instead it appears that the framing information was simply not applied to this aspect of the task. So the frame has definitely become part of the planning process, as evidenced by the effects elsewhere, but this is not a generic or general effect, since it does not extend to the discarding rule. This suggests that integration of the discarding mechanism was uneven – integrated into general play, but not into novel applications or learning processes.

The festival experiment then supported the idea that integration was important, albeit in a different way. For the first couple of questions the answers given did not fall into the pattern that was predicted by framing, or show substantial differences between conditions when they did. Although there was later compliance with the predictions made, this initial period of non-compliance with the framing can be explained along similar lines as the card-discarding non-adoption: the relevance of the information that the frame is providing is not immediately appreciated. This gradual adoption can actually be seen to have a parallel in the previous card game experiment where the number of aces played when an alternative was available rose in the second round, despite the general trend being towards less play. Again this suggests that integration of the relevant information was not complete initially, and therefore took some time to become part of an overall strategy. In both cases the information of the frame was not immediately treated as relevant to the decision making process.

The festival experiment provided more evidence for the importance of integration when comparing between the Over-Frame and question frame conditions. Where the question frame participants took time to integrate the frame information into a strategy, the Over-Frame participants did not integrate the information at all, although they showed signs that they knew it was there. As a result, they produced a chaotic pattern for the first couple of questions where their responses were unpredictable before falling back into a consistent pattern with the neutral condition – demonstrating that it was this additional information that made the initial difference. Again, this is potentially explained by the idea that the information was not sufficiently integrated to be relevant to the decision making process.

Finally the herbal study showed the same pattern of integration, taking a few questions to be consistently applied, that was seen in the festival task. This provides consistency of observation between both experiments and framing types. Additionally, in the festival experiment it also showed *lasting* strategic integration in the final unframed questions. This latter point is important because it supports what would be expected by the concept of integration into strategic planning – that the effect would stick around and be relevant after the specific supplying of information was removed. Particularly because in this instance it would be unlikely to be bias toward a simple habit (that participants had gotten used to picking one side), as the event in that experiment suggested that a bad outcome had arisen as a result of that very habit. Additionally, integration helps to explain why the event in that experiment did not have the anticipated effect on future decisions – the information in it was not integrated – or at the very least not as much as the previous frames. As a result it was non-predictive of response.

Integration Rethought

What all this suggests is that to see integration as simply being a perceptual and systematic matter is to overlook an important part of the process. The differences that are being observed are not linked to perceptual mechanisms; all evidence thus far is that that remains consistent. But the evidence also supports the theory that there is a semantic element to integration. Different strategic

decisions are being made according to what is understood about the task, and frames can only be applied where it is understood that the information applies to that element of a task. Integration is not simply the raw information that is then passed on to processing, but also the means by which that information is processed into a form that we reason with. Integration on this level is the difference between seeing a teapot and knowing that 'this can be used to make tea.' Note that this is not ignorance; in all cases the participants understood that the information *could* be applied to that area, it is that when decision making occurred that application was not taken into account – it had not been integrated.

This is also not simply a case of a learning effect. In the case of the card game it was illustrated that what happens when a frame is not initially integrated and then never re-presented – it has no effect and never took hold, even when the discarding mechanic was subsequently understood. In the other two studies, there was no learning effect to be had. Frames were not predictive of success nor did they punish non-compliance. If this evidence was due to a learning effect then the feedback should actually have established the irrelevance of the framing mechanism, but instead the frame became gradually *more* influential in affecting decisions. The information of the frame was gradually becoming *more* important in the course of the task – it was being integrated more completely.

These results do not provide a full accounting of why and how information is integrated, but they do establish beyond reasonable doubt that integration is an important factor for framing in ongoing tasks. The question that this naturally raises, therefore, is why integration has not been noted as important to date in single-choice paradigms.

The answer is actually very simple – there is a lot less that can occur in a single decision. There is one question, one decision and one result. As a consequence, things are either framing or they are not, and have no chance to be effective down the line or in the future. If there is no discernable result as the result of a frame then it would be assumed that the frame was simply not biasing – which is therefore one of the most important things this research has to say for previous

research. This experiment has established that frames are not necessarily applied instantly, but that in a task environment they can become embedded after a few iterations. The assumption that has existed previously - that something is either framing or it is not - is directly challenged. If the first few questions of the festival experiment were taken on their own, no result would be found for framing in the question frame condition – a null result using the Asian flu methodology of framing, a robust and well-established technique. What this implies is that the assumption that we know what is framing and what is not may very well be far from accurate because of the reliance on these single-decision mechanisms. If framing can require time to become effective, if framing can work over time, then the assumption that what works in a single decision holds true for when such decisions are taken in an ongoing dynamic environment seems self-evidently erroneous.

Another issue the concept of integration raises is the lack of range in measuring effects in previous research. The card game study showed this most potently with the complete lack of framing in the discarding element of the task and highly significant framing for the playing of Aces. Whilst information was framed, and this had an effect, it did not have an effect *everywhere*. Integration anticipates this sort of result and provides an explanation for it. If this were a single-decision experiment and discarding the only variable being measured however, it could quite easily (and erroneously) have been concluded that there was no framing effect occurring. Again, serious questions have to be raised about the appropriateness of the single-decision paradigm that has been so prevalent to date. Not that the results are necessarily untrue (clearly, the basic principles of framing have been reapplied here) but rather that there is the potential that it has been guilty of a series of type two errors, finding no result where in fact there may well have been one that the experimental designs were not equipped to detect.

The enhanced understanding of integration adds a significant degree of complexity to the concept of framing. Whilst the superficial observation that the information needs to be understood to be used is obvious, the idea that a frame can have an effect in one area but not another is not, and the enhanced

understanding of the processes explains how this can occur. Framing has generally been seen as an either/or proposition, but the evidence from these studies is that there can be an element of 'both' to that equation. Framing may not necessarily affect the areas that it is expected to, and may impact on areas that were not anticipated by the same measure. The key here is that a null result seen from a single metric may not indicate a lack of framing, or a lack of effect.

Further considering the implications of this for previous theory, there are some parallels with the concept of accessibility as noted by Kahnemann and Tversky. Accessibility is the concept of how available certain properties are in different contexts; an ambiguous figure that can either be '13' or 'B' given the surrounding context for instance (Kahneman, 2002). Integration touches upon some of the same ideas – that understanding can differ according to how information is processed – however it is distinct as they work at different levels. Accessibility is defined by information that has *been* integrated because that information is being understood differently.

Where integration differs is that there is information that could be potentially biasing but that is not processed to enable that to occur, or that an area which could be biased is similarly not understood. Any knowledge or information has the potential to have an effect on a person's thinking or reasoning. Integration does not concern the effectiveness of the information itself, but rather to what degree that information has been understood in order to be in a position to influence thinking.

Consider, for example, a driver who lives near to a school. On one side of the school is the entrance, and as is common this particular road is covered with slow signs and warnings. The driver reacts to this contextual information by slowing their average speed, and paying more attention to check for stray children who might run across the road. On the other side of the school there are no slow signs or warnings, but there are holes in the playing field fences and hedges where children might seek to take a short cut either to or from school. Would the driver be expected to slow down and be careful on this road too?

Several factors would come into play here, obviously. But the basic behaviour can be explained as a matter of integration. At a relatively low level of integration, the driver would not consider slowing down or paying more attention – they do so in the road with the entrance due to the contextual information, but that information has not been fully processed and as a result they are simply reacting to the surrounding environment. At a higher level of integration, however, a driver would possibility be expected to take more care on the second road as well, because whilst the direct environment is no longer cuing that response, the association of 'there is a school nearby, I must slow down' has been made in their mind. In this way differing levels of integration can be potentially predictive of behavioural responses.

Integration is therefore redefined as being the degree to which information is available to be used in formulation, being constrained by both perceptual and cognitive limitations.

Formulation

The second significant trend in the data that this thesis presents is the effect of framing effects on factors beyond and independent of what decision is reached. The implications of this are significant, and provide the evidence that framing influences do not simply influence the outcome of a decision, but rather the manner in which that decision is reached in the first place - formulation. Frames affect decision making architecture, the manner in which decisions are reached at all.

Experimental Evidence

That frames have an effect beyond simply shifting an opinion can be seen across the studies. Primarily it can be observed in the confidence measures for both the herbal and festival experiments, where confidence was shown in both cases to be directly affected by framing. Importantly in both cases it was shown to vary both compared to a neutral condition, and also *within* framing, where another factor interacted with it – feedback as the most notable instance in the festival study. Participants reacted differently to feedback as a result of having been framed compared to the neutral condition. This suggests that it was the act of framing

that was creating and/or enabling the differences. It was not that there was simply more information available, since participants reacted in a different manner by frame despite having received the same level of additional information. Similarly in both experiments the presence of a frame affected decision time measures above and beyond any differences simply associated with additional words or additional semantic content to be processed. This result is particularly significant because it was demonstrated that these systematic differences in additional factors arise even when the actual *decisions* being made remained constant. Not only this, but in the herbal study where the decision was separated from the framing device, participants took longer to read the decision section and think about the choice they were making. From a classical point of view, frames should influence the inclination of a person to make one choice or another, particularly opinion-based frames such as the one in that experiment. No additional, useful logical information was introduced to the process so it should not be expected to see an increase in processing time for the decision itself - unless the way in which that processing is occurring has changed. So, we know that framing has an effect on factors beyond simple decision making, framing alters the way different factors interact, and additionally framing can have an effect on additional factors without actually framing anything.

Formulation Rethought

This is significant for several reasons. First and foremost it is significant because it tells us that the decision that was made is not the only thing that matters when framing occurs, and consequently should not be the only thing that is measured as was noted above. Another implication however is that when taken together this data actually suggests something that goes farther - that framed information is affecting the *way* in which information is processed. A traditional view of the means by which a decision is reached is relatively mechanistic and input-output determined. A range of outputs is possible, but due to different input, like a programmable robot that will go to a variety of different destinations. What this suggests is that framing actually alters the means by which those same instructions are carried out. In the case of that metaphor a different vehicle

altogether is being used instead that might struggle to go up a ramp, or more successfully traverse some sand as a result.

It is the range of results obtained that suggests this is true. If information was being processed in the same way in framed and unframed examples and simply differing in output, you would expect to see consistency in time taken (after accounting for word length and semantic content) since the same basic processing factors would be performed. That consistency *can* be seen *within* the condition between questions, but it cannot be seen between framed and unframed data. Similarly you would expect to see consistency of the reaction within confidence to feedback. You might see a difference between the framed and unframed conditions, but the relationship between the different feedback types should be consistent when framed or unframed – unless the relevant information is being treated differently as a result of the information being framed.

It is for these reasons that it seems most likely to suggest that information is actually being processed and dealt with differently as a result of being framed. That the manner in which the information is presented has shaped the method by which it is assessed and disseminated. Remember that with framing, and indeed bounded rationality in general, the point is that the information itself is generally of the same logical content. It is the context – the bounds – which results in that information being assessed differently. What this research suggests is that it is not simply the conclusions that are reached which are different, but also the *manner* in which those conclusions are reached which varies.

It should be noted at this point that it is understood that the argument about formulation being made here is not conclusively supported. It is believed that this evidence makes this explanation the most likely, and that previous research supports the plausibility of this framework but additional work is needed to provide a greater degree of certainty. However, what should certainly be clear regardless of this is that frames have a great deal of impact on the formulation stage. Not just that it might take slightly longer to process the additional

information, but that there are substantial differences in the way in which information is handled. Even if the hypothesis about differential processing is not supported, the implication that frames *do* have a particular effect on processing beyond the simple introduction of information is evidence of a significant effect on its own.

Rebounded Rationality

The trends detailed above show that both integration and formulation are significantly more complicated as cognitive processes than was first assumed. However, in using bounded rationality to explore the concept of adaptation in tasks, that framework has also been used to make observations about framing effects, and bounded rationality as a whole. What the evidence suggests is that there is a need to rethink and reassess bounded rationality as a theory.

The original model's initial proposition was that integration determined what was understood, which then fed into planning processes which gave an outcome in the manner of traditional input-output mechanistic models. This research has demonstrated that this is an over-simplification of both processes, but more significantly it challenged several of the assumptions that the original predictions were based on. Framing was shown not to be an either/or proposition, but to take time in a given context. It was shown that single decisions were not sufficient to assess the impact of a frame and that differences occurred outside that metric. It was shown that feedback mattered and therefore that previous experience must also be relevant. All of these observations run contrary to the implicit assumptions of bounded rationality as a whole, and framing effects specifically.

Reassessing previous work the most significant flaw that presents itself is the overly reductionist approach. A majority of prior research relies upon scenarios constructed where two things are true: there is a single choice to be made or judgment to be rendered in discrete terms, and that once the task is complete the study ends. As simple thought experiments this approach is fine, and indeed there are many instances in everyday life where a decision can be represented in these terms. The problem with this approach is, of course, that whilst that

individual decision can well be modeled in that manner, doing so removes the complexity of the surrounding scenario that also determines the outcome. As an example, consider the penalty shootout in a football match, and specifically the English national team's performance in them in major competitions. England have something of a reputation for exiting tournaments when a match goes to penalties – despite the fact that the players involved in taking them inevitably are familiar with the process and far more successful at scoring in practice and when in action for their clubs. Why does this occur? Whilst no definitive answer can be offered, the general assumption is that pressure negatively affects the players – especially since once a reputation for losing in that manner has been established nerves seem all the more likely to kick in.

This illustrates the problem with a reductionist approach to decision making. The actions in both the cases (club level and internationals) are the same, but the context wildly different in a way that will produce wildly different results. And even if the single point representation *does* try to capture this sort of difference, there is still a significant gap between taking the first and fifth shots in such a contest. Prior information is important, as is what comes next. Ultimately the obvious solution is to approach the task as part of a whole rather than separate out its individual parts – and this research has demonstrated that being in an ongoing task brings specific properties.

The irony of stating this is that the point of bounded rationality has always been to see decision making as being determined by the set of circumstances it is made in: cognitive, social, perceptual and so forth. What this evidence suggests is that we can add another category to that list – experimental. By adopting these standard methodologies decision making study itself has to date been significantly bounded.

A note of caution should be sounded here. Bounded rationality has shown itself to be a useful toolbox for both providing better representations of human decision making than existed before it, and also for supplying the basis on which decision making was understood for this work. This thesis offers some new perspectives and illustrates significant areas in which the current theory is

insufficient, but that should not be misread as being a complete repudiation of the existing body of work out of hand. Existing theory is a useful baseline to work from – indeed, the frames that were used in this thesis were intentionally drawn from preexisting work for just that reason. As an understanding of the mechanics of judgments and decision making it remains both theoretically and practically relevant. The fact that, broadly speaking, the Asian flu frame successfully influenced decision making in a task-based scenario actually illustrates that prior work is not rendered irrelevant, simply shown to be insufficient.

Rationality in Tasks

Having established that it is necessary to redefine bounded rationality for an expanded worldview, this section will present a framework for doing just that. As would be expected, the basic components of this theory have already been explained in the previous sections and therefore will not be unduly repeated.

It is worth noting, however, that this is, and intends to be, a starting framework. This work does not presume to offer a definitive answer to the question, but to further understanding and enable additional knowledge to be pursued as a result. Several areas for expansion and additional work will be detailed in the subsequent section for precisely this purpose.

The core of this theoretical re-structuring is the division of framing effects into two components; framing and actuation.

Framing

Framing is any variation in presentation of information that has the potential to result in alternations to the processing of information and decision making.

Previously framing referred to structural alterations to information presentation that *did* have an effect on decision making. This definition expands the idea of framing to encompass 'non-effective' framing intentionally. It removes the issue of success from a definition of framing, and more usefully defines framing as simply being the variation within information presentation.

Actuation

Actuation is defined as the success or failure of a frame to have an impact on cognitive processing. It adopts many of the properties previously associated with framing as a whole.

Note that the definition is still divorced from simply being concerned with decision making, so the additional effects and impacts that framing has can still be considered under the banner of 'framing,' as they should be.

Actuation is itself defined by a number of factors, listed below. These are the primary factors that have been identified by this work, although it is anticipated that these are not a comprehensive list and other elements may also emerge as the result of future research.

Potency – The ability of a frame to impact decision making.

This factor would encompass a majority of previous research, which would be seen as being concerned primarily with scenarios where high potency frames were applied to limited trial environments. It also enables the generally appropriate primary focus of most research to be maintained. The distinction also allows for the possibility of less powerful frames which might be ineffective in single-decision scenarios having an effect when implemented over a longer period.

Positioning – The location of the frame relative to information gathering. Covers proximity to framed concept, as well as repetition and reviewability.

This factor is necessary to account for the fact that where a frame is presented is of significance. The herbal study established that frames did not need to be directly embedded in the relevant information, but the work also demonstrated the importance of repetition for some frames, and that the same position in different tasks may produce different results.

Noise – The level of additional information in the environment that may obscure or otherwise prevent a frame from being noticed.

This factor is reflective of the fact that the complexity of the task, or environment, can affect application of the frame. This was seen in the variable

application in the card game task. It touches on issues of attention and perception as well, as these could also present barriers to frame adoption.

Internalization – The degree to which a frame has been integrated into individual processing.

Recognizing that frames retain some of their influence even once they stop being presented, this factor makes a distinction between a one-off choice that lead to an implication, and an association that has been solidified in a participant's mind.

Effect Scope - The degree to which non-primary effects are also caused by the frame.

This factor concerns the additional measures that were noted by this thesis. They are taken as indicators of differences being made at the processing level. This factor is different to the others since it is observational rather than predictive, but important as the confidence measures showed. Confidence is not anticipated to be the only factor relevant to this point, but it is used as an example of a factor that is both relevant and demonstrably affected by framing.

The effect of this re-definition of framing effects is that the theory now provides the required dimensions to account for the results observed in the work of this thesis. At the same time it does not contradict or eliminate any previous work. All the single-point decision work that has come before is still relevant and can be understood within this framework – however, now additional effects can also be accounted for.

Applications

This research has a wide range of potential practical applications. There are three main ways in which this section will discuss how it could be used: engineering desired behaviour, avoiding undesirable behaviour and predicting behaviour. In all of these examples the primary application of this theory as it stands right now would be as a series of guidelines to be addressed by expert (or possibly informed novice) specialists. Rather than provide specific criteria of what should be done in given situations, the theory as outline above provides categories to assess and address as necessary. In this way it can be best thought

of as a diagnostic tool akin to cognitive walkthrough or other such usability guidelines, and it is no accident that the application of this research is suggested in broad guidelines rather than specific remedies or solutions.

Engineering Behaviour

Frames and bounded rationality lose their effectiveness if they are made explicit or noticed by the participant in some other way. The frames in both the festival and herbal studies in particular relied upon participants accepting the unreality of the situation that, for instance, the 1/3 automatic success of the Asian flu example could apply to every situation. That is not to suggest that frames do not exist in the real world; they clearly do and have been shown to work in such situations. The point is that the frames worked precisely because within the context (the *bounds* of the situation) they appeared in they were plausible and appropriate. The challenge of applying this work to the real world is not only in finding appropriate situations to use it in, but also in finding a way to apply it that does not become self-defeating. Something that this thesis has aptly demonstrated is that the effect of frames very a great deal according to the context that they are placed in – tasks over single decisions, position and soforth. It is certainly beyond the scope of the evidence in this work to provide a list of exactly how and why frame application may vary in a given context, so the role of an expert becomes necessary to translate the general abstract understanding into context-specific applications.

An example of where it could be used to engineer desired behaviour is the world of online advertising and selling. Here the objective is obviously to have more consumers click through to a webpage from an advert, and then to make purchases once they have done this. What makes this theory specifically applicable to this area is that online interaction takes place in a highly engineered environment. Whilst a great deal of the interaction cannot be predicted ahead of time – real world distractions, differing monitor setups, etc., etc. – for the most part the environment that any two people experience when visiting a given webpage will be largely identical. Even with personalization most sites run a 'theme' and a given layout that all users experience in the same basic way. This allows for more precise application of the principles and design to

emphasize them. Of particular interest would be the concept of internalization, because it is such a desirable outcome if the objective is to sell something (and particularly for engendering repeat customers). Trying to ensure that the basic concepts of purchasing the product or using a service are instilled would arguably be more important than actual click through or sales, initially at least. If it manages to impart a habit or behaviour, that will be far more useful over the long run than a one-time successful transaction.

Preventing Behaviour

A counter-example of where this same information could be used to prevent mistakes being made as a result of framed information would be high-density decision-intensive environments with high consequences, such as battlespace management or air traffic control rooms. In these setups high-skill individuals make constant decisions which often carry high penalties if a mistake is made or a failure occurs. Ideally, a decision maker in this context would be provided with the relevant information in the most useful manner and then allowed to make that decision otherwise unbiased. The danger is that the inherent biases that people carry with them could cause the decisions to be biased, as could inadvertent framing of the information. It is not implausible that information coming into a battlespace could itself be framed even if that framing is unintentional. Soldiers conveying information from a front line may not be reporting with complete objectivity, after all.

In this context the research could be used as a guide for what to avoid in order to lessen the chance that information is being framed or biased. An advantage of re-conceptualizing the concept of framing in the way that has been done is that it treats all information presentation as potentially leading, and therefore does not require that 'frames' are specifically identified to be dealt with. Rather the factors involved in actuation can be specifically addressed. Of particular interest for this would be internalization. Studying systems to be aware of whether participants are internalizing biased choices for their decision making is both quantifiably achievable (past decisions can be tracked against projected baselines) and shown to be newly relevant by this research. Previous theory would have assumed that a given decision had the same chance of affecting a

choice in its first or 60th iteration, but as this thesis has shown even well established frames can take time to 'come online.' Thus the theory would support looking for ongoing and emerging biases, as well as detecting more subtle frame effects, and providing some insight into how to address these – simply changing the way the information is presented will not be enough as by that point the tendency will be integrated into a way of thinking.

Additionally, this theory would potentially be able to link other phenomena back to framing. As was demonstrated in the thesis, framing can have an effect on confidence even when the actual decisions being taken do not change. Battlespace management requires confidence to undertake – being an arena that is by definition filled with danger and potential flaws, confidence is a necessary quality to give appropriate orders, and dangerous both in its absence and also when there is too much. Overconfidence or under confidence would be something that could both be noticed, and then potentially ascribed to the framing that was present. This sort of secondary reaction, and being able to look for it could be potentially important since it might represent a way to systematically address what would otherwise generally be thought of as a 'character' flaw rather than an environmental effect.

Predicting Behaviour

The third manner in which this research could be applied is in understanding, analyzing and predicting behaviour patterns. As has been raised already elsewhere in this thesis, an area with a great deal of potential for this is cyber influence, and specifically social media as a conduit for that.

With the influence that social media currently has in society, and the expectation that the underlying principles that drive it will continue to be influential in years to come, this is an area where there is a great deal available to be understood and there is good reason to do so. Whilst the data it provides is somewhat hard to read at times due to the sheer volume and difficulty associated with picking out the relevant information, the actuation factors listed above provide again a framework for both understanding behaviour and predicting it.

This actually provides a good example of an area where adaptability is key for the theory. Clearly there are a great deal of specific contextual issues that arise in the area of cyber influence – interactivity of frames (opinion), asynchronous communication, dynamic environment, personal ties and affiliation etc. Context specificity is something that should be embraced, and the overarching principles used as a framework rather than a definitive answer. Indeed, specific social networks are going to have specific norms and interaction paradigms that conflict with others even utilizing the same platform for communication. On twitter the hashtag #tcot (standing for 'top conservatives on twitter') is commonly used by conservative political operatives as a default so that other users can simply search for that tag to see what is driving the day in terms of stories on that side. There is no equivalent example in such widespread use on the liberal side, which tends to appropriate hashtags for a given day and event. The point is that this is a clear organizational difference between two relatively similar (politically driven) groups on the same communication platform. In terms of the theory, the use of the #tcot hashtag would enable a framing tweet to gain relatively strong positioning in a way that would not be possible in a different group. Context is key, but again in this example the theory provides a way of understanding the likelihood of that framing spreading or being internalized.

Another potential application of this work is that it could be used to actually identify when people have been influenced. One of the main issues that framing and theories of cyber influence and other work face is determining when an attempted influence is actually working. For laboratory work such as this, control groups and baselines can be established, but in more ecologically valid situations it is often impossible to compare between groups in this way, so it is hard to know if an application is actually working or not.

But this research *does* provide a means of looking at that problem. It has shown that decision making is not the only factor that can be affected by framing, but also confidence and reaction times. Additional effects are notable when participants are successfully framed, and it is these additional effects that can provide the basis for establishing if a frame has been successful or not. In a task-

based environment with high monitoring, reaction and decision times can be monitored for changes against a baseline reading from previous performance on that task. Alternately when considering an area such as cyber influence, there is the potential to use the fact that feedback is available in that area. People are not simply consuming, but also broadcasting, and the semantic content of their published content, as well as their noticeable actions, could provide insight into how their confidence levels have (or have not been) affected by exposure to the framed material. In any case, the existence of secondary effects enables additional streams of information to be used in understanding if influence has occurred or not. These should be able to be employed, along with other methods, in an attempt to triangulate an answer from multidimensional sources.

Autonomy

Finally, it is worth considering the implications this theory could have for the design of autonomous systems. Whilst there is some obvious theoretical distance between this work and artificial intelligence at this point, at the same time it is believed that this framework could provide some basis for innovative work there as well.

Previously frames were considered primarily in terms of their potency as defined by their interaction with people. Accounting for this in an artificial setting was always going to be difficult because of the circular nature of such a process – if you can only define a frame by interaction with a person, then a human has to be in the loop for an autonomous system to see it removing the autonomy from the calculation.

This work does not entirely solve this issue. Potency is still a quality that remains somewhat defined by people. However other factors of actuation are more quantifiable. The structure of differential information representation, as a frame is now defined, *can* be objectively mapped and discriminated between on a basic level. Similarly, positioning can be defined in terms of information location and the units between those points (page views, distance on a screen) as can some environmental noise (additional windows, colour variety, etc.) This cannot provide for all the complexity that goes into framing any more than the theory

pretends to definitively represent the area. But what they do provide are the working basics for units of framing to be built up and understood. Automated systems might not be able to actually detect or understand framing, but by developing and applying intelligent algorithms that look for these qualities – and specifically combinations of these qualities – then there emerges the possibility of framing events, information or scenarios to be developed. An autonomous system could monitor information flow and highlight for a human operator where information might be framing an opinion so that that operator can make a distinction for themselves. Frames tend to lose potency once they are specifically looked for or considered, including such examples as the Asian flu classic. By using these principles to manage information flow to a human operator, there is the potential to avoid biasing said information in a way that otherwise would go unnoticed.

Further Work

This work redefines a previously well-mapped area of theory. Consequently, there is a great deal of follow-up work that can be undertaken as a result of the new questions it raises.

It seems prudent to first acknowledge that there is a great deal of basic follow-up work to be done. Research should be challenged and there should be attempts to disprove it, including the conclusions of this thesis. Subsequent work involving task activity, confidence, and feedback to further examine the relationships therein should be welcomed, although this section will not address these directly outside this paragraph in favour of broader ideas. That said, the theory provides obvious testability for the separate factors of actuation to be investigated, as well as the more general theories of integration and formulation.

The most obviously speculative theory drawn in this section is that of framing causing different cognitive strategies to be employed in decision making. There has already been some work looking at brain activation patterns in single-decision work that supports this hypothesis as plausible (Deppea et al., 2005; Gonzaleza, Danaa, Koshinob, & Just, 2005; Martino, Kumaran, Seymour, & Dolan, 2006) but there is clearly need for further examination of the idea. There are a

number of potential problems to be overcome however, the most prominent of which being that brain imaging techniques give generally bad temporal resolution with current technology – and this research deals with consecutive, temporally close occurrences. The hypothesis also allows for the idea that different cognitive strategies could emerge in the same region of the brain, so the difference being sought could potentially be undetectable with current generation machines, particular fMRI.

Nevertheless, it remains an interesting area of potential research. Comparisons could be made between brains that have been primed and unprimed by a framing effect to look for a difference, enabling a snapshot to potentially show deeper cognitive differences. Alternately fMRI could be used to locate the associated brain regions, and then EEG or equivalent used for temporal examination. What is clear in any circumstances is that a series of studies would be necessary to address the hypothesis with any certainty.

Another area that would expand this research in a significant way would be to consider the dimension of expertise, and pre-existing knowledge and skill. One of the criteria applied throughout this thesis was that the tasks should be novel in some regard; that participants were learning as they went along, at least partially, because that is the time when a person would be expected to be most open to influence from frames and other means of directing opinion. This should not be seen as a flaw, since it represented the most appropriate way to ensure a level playing field between participants. Expertise itself was carefully controlled for and no significant effects were found associated with it. But whilst the issue of expertise lies intentionally outside the scope of this thesis' work, it nevertheless represents an interesting source of potential work. The extremists that were identified in the herbal study are an example of how pre-existing biases can overrule framing effects; it stands to reason that pre-existing experience that was *logically* based could have a similar impact.

This research has demonstrated that feedback can overcome a framing effect, although it doesn't necessarily do so. Experience would be predicted, therefore, to follow a similar pattern. On one level it would be anticipated that task

familiarity would simply overrule any potential framing effect, since experience would be providing the methodology by which a decision was being made and presumably be given more cognitive weight than current information. On the other, people still demonstrably adapt to changing circumstances and respond to new information, which would presumably include new information that happened to be framed. So some sort of relationship should be present between the two conflicting factors. Experience would, presumably, represent another factor that would influence frame actuation.

A third suggested area for theoretical research would be to look at the interaction that appears to occur between framing and feedback. This finding was shown in the festival experiment, but intentionally not investigated any further because the questions it raises are significant enough that it could potentially be a body of work itself. For the purposes of this thesis it was sufficient to know that there *was* a relationship between the two factors, and as supporting evidence for the idea that framing affected more than just the decision being made.

The result raises greater questions, however. Why were framed participants more confident with qualitative feedback? The suggested hypothesis is that it allows them to see the information subjectively, and this is something that could stand to be more empirically tested. That hypothesis also might flow back into the expectation of differences in processing – different types of feedback could generate different levels of confidence, which could be related to the way in which a problem is considered.

More than just this however, the result raises questions about feedback interacting with framing in general. Qualitative and Quantitative feedback are useful distinctions, but are not the only way in which feedback can be presented, nor necessarily the most appropriate way of distinguishing information type. Quantity of information would be one factor, but also quality. The information in the latter two studies of this thesis was intentionally non-informative to avoid pulling participants to one particular conclusion, and to maintain a level of ambiguity. But what about situations where feedback is more explicit and direct?

The Card Game study suggested that this would eventually over-run a framing effect, although that was a frame located in the instructions. Would a repeated frame maintain some applicability in the face of conflicting empirical feedback? Clearly there are a great deal of unanswered questions, and this work has hopefully opened up a pathway to start addressing them.

A Final Word

The conclusions from this work should be readily apparent at this point. Context and information presentation can influence strategic formation, and framing effects have distinct properties when placed in an ongoing task paradigm. The evidence for these observations seems indisputable at this point, whilst the implications, applications and further work discussed in this section hopefully provide a basis for taking them onwards.

There hopefully remains room for a brief philosophical note from the author. This work was at least partially inspired by and driven from an interest in artificial intelligence and autonomous systems. There is clearly some distance between that area and where this thesis and conclusions it contains have ended up, but the significance of the larger abstract questions about artificial intelligence and autonomy is that they are the same questions that exist about human autonomy and intelligence – how do we think? How do we reason? Why do we choose to do certain things and not others? These are not easy or trivial questions. They are not simple or prescriptive; they are not a simple task to be replicated or a single skill to be aped. They are not emergent properties of a sufficient number of simple rules. Few things so aptly illustrate the complexity of the human mind as the persistent inability to create anything approaching an artificial correlate of it. As a consequence the same questions that have always driven psychology start to become those that drive AI, and vice versa.

So whilst the bulk of this thesis does not ultimately relate to autonomy and artificial intelligence it is hoped that it might at least partially serve as a reminder of the importance of interdisciplinary work and collaboration across interest areas. It is no exaggeration to say that this thesis would not exist without the questions that were raised from exposure to researchers whose perspective

and interests were greatly divergent from those the author started with. As a small, anecdotal and quantitively unsupported observation - the benefit of making an effort to listen and think outside your comfort zone is something that should not be taken for granted and can reap unexpected benefits. Hopefully, this thesis can provide a small illustration of that potential.

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The UK Vetting Agency – Wait, I'm *trustworthy?*

Salisbury People – For getting me through corrections. You may not know what you did, but you helped.

Kahneman and Tversky – You guys are awesome, and I've never even met you.

The Fine City of Bath – for having far more to offer than I imagined possible when I first arrived.

Widcombe Hill – for keeping me fit. Although, seriously, who put the university at the top of you?

Stephen Payne – I hated pretty much all my corrections… but I suspect that doing them made me a better scientist.

Everyone Else – I can't name you all, but you mattered. Cheers.

Appendices

The Experiments in this thesis required a great deal of materials and text. If these were printed verbatim in this section they would add a great deal of largely unnecessary space.

Consequently, a sample of all appropriate materials are presented here. Some have been compressed to save space: primarily questionnaires where a space would otherwise have been left for a subject's answers: no words have been changed or removed. A full archive of all the materials used in their original form can be found on the CD attached to this work. Alternatively the full archive can be requested by emailing the author at timothyharrison@gmail.com. Raw results data is not included on the CD, but may be supplied upon request to the same address, as can all records of statistical tests and any materials that may have been omitted by accident.

One: Solitaire Study - Pre-Study Questionnaire

Questionnaire

The purpose if this questionnaire is simply to document what you understand about the game of solitaire prior to playing it. Answer the open-ended questions to the extent that you feel appropriate.

Part 1

Answer the following questions by circling the appropriate number indicating how strongly you feel by the following scale:

1 – Strongly Agree

2 – Agree

3 – Neutral, a bit of both, neither agree nor disagree

4 – Disagree

5 – Strongly Disagree

I know how to play solitaire

1-------2------3------4------5

I like having a definite answer to things.

1-------2------3------4------5

I have methods for solving problems that I stick to.

1-------2------3------4------5

I'm not very good at strategy games

1-------2------3------4------5

Improvising is a strength of mine

1-------2------3------4------5

I get can get lost in little details

1-------2------3------4------5

I try to avoid ambiguous solutions

1-------2------3------4------5

I enjoy new challenges and problems

1-------2------3------4------5

I work at things methodically

1-------2------3------4------5

I'm good at card games in general

1-------2------3------4------5

I consider myself to be good at solitaire

1-------2------3------4------5

I sometimes forget about the big picture

1-------2------3------4------5

I find it hard to come up with new ideas when faced with a problem

1-------2------3------4------5

Part 2

What do you understand about the game 'Solitaire'? Give a brief overview of the basic purpose of it, and the necessary equipment.

How do the constituent parts fit together? In what way do they interact?

Do you pursue any particular strategies when playing a game? Can you think of any tactics you employ? How do these work, and why do you use them?

Do you play any other card games on a regular basis? How many would you say you are familiar with? What are they?

Do you play any other games – of any sort - regularly? If so, what are they, and how often do you play? Did you play any in the past?

Two: Solitaire Study - End Questions

As a final question, how do you feel you adapted to the change halfway through the experiment? Do you feel it helped or hindered your game? Did you change any of your strategies, or did you fit in into existing ones? If so, how?

Do you have any other comments about the experiment and what you did in general?

Three: Card Game Study – Pre-Study Questionnaire

Questionnaire

The purpose if this questionnaire is simply to document what you understand about card games. Answer the open-ended questions to the extent that you feel appropriate.

Part 1

Answer the following questions by circling the appropriate number indicating how strongly you feel by the following scale:

1 – Strongly Agree

2 – Agree

3 – Neutral, a bit of both, neither agree nor disagree

4 – Disagree

5 – Strongly Disagree

I enjoy logic problems

1-------2------3------4------5

I regularly engage in puzzles in the paper such as Sudoku or Crosswords

1-------2------3------4------5

I like to have an overall plan when approaching a problem

1-------2------3------4------5

I'm not very good at strategy games

1-------2------3------4------5

I play games recreationally

1-------2------3------4------5

I'm happy to let others take the initiative in games.

1-------2------3------4------5

I try to avoid ambiguous solutions

1-------2------3------4------5

I'm a systematic thinker

1-------2------3------4------5

I'm quite a competitive person

1-------2------3------4------5

I'm good at card games in general

1-------2------3------4------5

I'm happy to develop ideas on the fly

1-------2------3------4------5

I sometimes forget about the big picture when making a decision

1-------2------3------4------5

In games, a good offense is often the best defence

1-------2------3------4------5

I don't really care about winning and losing

1-------2------3------4------5

Part 2

Are you familiar with the Card games 'Uno', Crazy 8's' or some other variant? Describe how familiar you consider yourself to be.

Do you play any other card games on a regular basis? How many would you say you are familiar with? What are they?

Do you play any other games – of any sort - regularly? If so, what are they, and how often do you play? Did you play any in the past?

Four: Card Game Study – Post-Study Questionnaire

Your final score:

Your position in the game:

Now that the game is over, how did you feel about playing it? What strategies did you initially intend to employ? Did this alter at all as the game progressed?

Given the chance to play again, what might you do differently next time? Would you use the same strategy?

Please also feel free to offer any other thoughts or comments on your playing experience.

Five: Risk Taking / Impulsiveness Questionnaire

1.
For each of the following statements, please indicate the **likelihood** that you would engage in the described activity or behavior if you were to find yourself in that situation. Provide a rating from *Extremely Unlikely* to *Extremely Likely*, using the following scale:

1	2	3	4	5	6	7
Extremely Unlikely	Moderately Unlikely	Somewhat Unlikely	Not Sure	Somewhat Likely	Moderately Likely	Extremely Likely

1. Admitting that your tastes are different from those of a friend.
2. Going camping in the wilderness.
3. Betting a day's income at the horse races.
4. Investing 10% of your annual income in a moderate growth mutual fund.
5. Drinking heavily at a social function.
6. Taking some questionable deductions on your income tax return.
7. Disagreeing with an authority figure on a major issue.
8. Betting a day's income at a high-stake poker game.
9. Having an affair with a married man/woman.
10. Passing off somebody else's work as your own.

11. Going down a ski run that is beyond your ability.
12. Investing 5% of your annual income in a very speculative stock.
13. Going whitewater rafting at high water in the spring.
14. Betting a day's income on the outcome of a sporting event
15. Engaging in unprotected sex.
16. Revealing a friend's secret to someone else.
17. Driving a car without wearing a seat belt.
18. Investing 10% of your annual income in a new business venture.
19. Taking a skydiving class.
20. Riding a motorcycle without a helmet.
21. Choosing a career that you truly enjoy over a more secure one.
22. Speaking your mind about an unpopular issue in a meeting at work.

23. Sunbathing without sunscreen.
24. Bungee jumping off a tall bridge.
25. Piloting a small plane.
26. Walking home alone at night in an unsafe area of town
27. Moving to a city far away from your extended family.
28. Starting a new career in your mid-thirties.
29. Leaving your young children alone at home while running an errand
30. Not returning a wallet you found that contains $200

Six: F-Scale Authoritarianism Questionnaire

Please indicate how strongly you agree or disagree with each of the following statements, by making a note of the number of the appropriate response.

Strongly Disagree(1) - - Disagree(2) - - Not Sure(3) - - Agree(4) - - Strongly Agree(5)

1. Deviant sexual behaviour between consenting adults may be disagreeable but it should not be regarded as a crime.

2. No sane, normal, decent person would ever think of hurting a close friend or relative.

3. Many of the radical ideas of today will be the accepted practices of tomorrow.

4. People who want to imprison or whip sex criminals are themselves sick.

5. Obedience and respect for authority are the most important virtues children should learn.

6. Young people sometimes get rebellious ideas but as they grow up they ought to get over it and settle down.

7. It is all right for people to raise questions about even the most personal and private matters.

8. Insults to our honor are not always important enough to worry about.

9. Sex crimes such as rape and attacks on children deserve more than imprisonment; such criminals ought to be publicly whipped or worse.

10. Most honest people admit to themselves that they have sometimes hated their parents.

11. Racial profiling is a necessary method of identifying potential terrorists in today's world.

12. Sex crimes such as rape and attacks on children are signs of mental illness and such persons belong in hospitals rather than prisons.

13. There is hardly anything lower than a person who does not feel great love, gratitude and respect for his parents.

14. What the young need most is strict discipline., rugged determination and the will to work and fight for family and country.

Seven: Introversion/Extraversion Questionnaire

Answer the following by choosing to what degree you agree, or disagree with each statement about yourself. Make a note of the appropriate response's number as it applies to you.

Strongly Disagree (1) - - Disagree (2) - - Agree (3) - - Strongly Agree (4)

1) I am a talkative person

2) I am generally quite lively

3) I enjoy meeting new people

4) I usually let myself go and enjoy myself at a lively party

5) I usually take the initiative in making new friends

6) I can easily put some life into a quiet social gathering.

7) I tend to keep in the background on social occasions

8) I enjoy socializing with people

9) I like plenty of bustle and excitement around me

10) I am mostly quiet when I am with other people

11) Other people would describe me as lively

12) I can get a party going

Eight: Festival Study Instructions For Neutral and Question Frame conditions

In this task you will be assuming the role of site manager for a mid-sized music festival called 'Wish'. You have been hired to oversee the day-to-day running of the site, and in charge of making sure that the event proceeds as smoothly as possible.

In the course of this task you will be presented with a series of high-level decisions about events occurring at the festival and the potential courses of action available. Your job is to make a decision between the choices presented, and attempt to run the best event possible. You will be given an idea of how successful you are being in your task by two feedback metrics: money and reputation.

'Money' represents the amount of money that the festival has gained, saved or lost, as a result of a decision you have made, compared to the projections for if the festival had been functioning normally or not decision was made. It is given in pounds sterling, and the starting point is zero.

Reputation is a measure of public opinion regarding the event. It is presented in the form of a public poll, with a baseline approval of 60%.

For both measures there are no guarantees that you can obtain a positive outcome. At times it may be a case of minimizing losses, or conversely of maximizing gains. Similarly, there is element of random chance to the outcome of these decisions: you can maximize your chance of success, but cannot guarantee it. As in real life, sometimes things may go wrong even if you make all the right decisions. All the decisions you make have the potential to affect which future decisions you face, and have consequences later on. You should consider the implications of the choices you make as a result.

For each decision you will be given a choice between whether to attempt to handle the problem on-site with the pre-existing festival resources, or whether to call in outside help such as the police, fire services etc. You must decide which is most likely to be appropriate in each case.

Having made this choice, you will then also be able to choose the level of confidence that you have in your decision, where 1 represents very little confidence, and 7 absolute confidence.

For each question, you will have a maximum of three minutes to both read and understand the situation, and then choose your response. If you fail to choose a response in the allotted time, it will be assumed that you did nothing, and your scores affected accordingly. It will always be better to choose an option than to not pick one.

Nine: Festival Study Over-Frame Instructions, External

In this task you will be assuming the role of site manager for a mid-sized music festival called 'Wish'. You have been hired to oversee the day-to-day running of the site, and in charge of making sure that the event proceeds as smoothly as possible.

In the course of this task you will be presented with a series of high-level decisions about events occurring at the festival and the potential courses of action available. Your job is to make a decision between the choices presented, and attempt to run the best event possible. You will be given an idea of how successful you are being in your task by two feedback metrics: money and reputation.

'Money' represents the amount of money that the festival has gained, saved or lost, as a result of a decision you have made, compared to the projections for if the festival had been functioning normally or not decision was made. It is given in pounds sterling, and the starting point is zero.

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For each decision you will be given a choice between whether to attempt to handle the problem on-site with the pre-existing festival resources, or whether to call in outside help such as the police, fire services etc. You must decide which is most likely to be appropriate in each case.

External solutions are more professional and accomplished, but may be delayed in arriving or otherwise held up. A problem will be solved 33% of the time.

Internal solutions are always on site and ready to go, but are less professional and able. They will fail to solve 2/3 of any problem

Having made this choice, you will then also be able to choose the level of confidence that you have in your decision, where 1 represents very little confidence, and 7 absolute confidence.

For each question, you will have a maximum of three minutes to both read and understand the situation, and then choose your response. If you fail to choose a response in the allotted time, it will be assumed that you did nothing, and your scores affected accordingly. It will always be better to choose an option than to not pick one.

Ten: Festival Study Over-Frame Instructions, Internal

In this task you will be assuming the role of site manager for a mid-sized music festival called 'Wish'. You have been hired to oversee the day-to-day running of the site, and in charge of making sure that the event proceeds as smoothly as possible.

In the course of this task you will be presented with a series of high-level decisions about events occurring at the festival and the potential courses of action available. Your job is to make a decision between the choices presented, and attempt to run the best event possible. You will be given an idea of how successful you are being in your task by two feedback metrics: money and reputation.

'Money' represents the amount of money that the festival has gained, saved or lost, as a result of a decision you have made, compared to the projections for if the festival had been functioning normally or not decision was made. It is given in pounds sterling, and the starting point is zero.

Reputation is a measure of public opinion regarding the event. It is presented in the form of a public poll, with a baseline approval of 60%.

For both measures there are no guarantees that you can obtain a positive outcome. At times it may be a case of minimizing losses, or conversely of maximizing gains. Similarly, there is element of random chance to the outcome of these decisions: you can maximize your chance of success, but cannot guarantee it. As in real life, sometimes things may go wrong even if you make all the right decisions. All the decisions you make have the potential to affect which future decisions you face, and have consequences later on. You should consider the implications of the choices you make as a result.

For each decision you will be given a choice between whether to attempt to handle the problem on-site with the pre-existing festival resources, or whether to call in outside help such as the police, fire services etc. You must decide which is most likely to be appropriate in each case.

External solutions are more professional and accomplished, but may be delayed in arriving or otherwise held up. A problem will be unsolved 66% of the time.

Internal solutions are always on site and ready to go, but are less professional and able. They will guarantee to solve 1/3 of any problem.

Having made this choice, you will then also be able to choose the level of confidence that you have in your decision, where 1 represents very little confidence, and 7 absolute confidence.

For each question, you will have a maximum of three minutes to both read and understand the situation, and then choose your response. If you fail to choose a response in the allotted time, it will be assumed that you did nothing, and your scores affected accordingly. It will always be better to choose an option than to not pick one.

Eleven: Festival Study Sample Decision, Neutral and Over-Frame Conditions

Decision 3

It is currently 1:30pm, and it will soon be time for one of the most popular acts on the line-up to take the stage, a particularly hyped-up and highly anticipated act from America. They were booked several months ago, but since that time have had significant chart success with their debut album and as a result a large crowd is expected, significantly more than would normally be found at this time.

Due to other commitments however, the band are late arriving. They are currently making their way towards the site, but have been held up by traffic of still-arriving festival goers. Security fears that the mood of the crowd could turn nasty if there is too long a delay.

The Police can be contacted to help with these matters by escorting vehicles through traffic if asked, but it is unclear if they will be able to find the band in time. Site management thinks they can alter some of the entry routes to ease traffic flow on the road that the band are on, but they will still be significantly delayed. They are due to play an hour's music, and the next act cannot be delayed due to contracts and tight scheduling.

Twelve: Festival Study Sample Decision, Question Frame Internal

Decision 3

It is currently 1:30pm, and it will soon be time for one of the most popular acts on the line-up to take the stage, a particularly hyped-up and highly anticipated act from America. They were booked several months ago, but since that time have had significant chart success with their debut album and as a result a large crowd is expected, significantly more than would normally be found at this time.

Due to other commitments however, the band are late arriving. They are currently making their way towards the site, but have been held up by traffic of still-arriving festival goers. Security fears that the mood of the crowd could turn nasty if there is too long a delay.

The Police can be contacted to help with these matters by escorting vehicles through traffic if asked, but it is unclear if they will be able to find the band in time. Site management thinks they can alter some of the entry routes to ease traffic flow on the road that the band are on, but they will still be significantly delayed. They are due to play an hour's music, and the next act cannot be delayed due to contracts and tight scheduling.

If the police are asked to help, there is a 66% chance the band will miss their playing slot.

If the site management alters the road system, the band will be in time to play 20 minutes of their set.

Thirteen: Festival Study Sample Decision, Question Frame External

Decision 3

It is currently 1:30pm, and it will soon be time for one of the most popular acts on the line-up to take the stage, a particularly hyped-up and highly anticipated act from America. They were booked several months ago, but since that time have had significant chart success with their debut album and as a result a large crowd is expected, significantly more than would normally be found at this time.

Due to other commitments however, the band are late arriving. They are currently making their way towards the site, but have been held up by traffic of still-arriving festival goers. Security fears that the mood of the crowd could turn nasty if there is too long a delay.

The Police can be contacted to help with these matters by escorting vehicles through traffic if asked, but it is unclear if they will be able to find the band in time. Site management thinks they can alter some of the entry routes to ease traffic flow on the road that the band are on, but they will still be significantly delayed. They are due to play an hour's music, and the next act cannot be delayed due to contracts and tight scheduling.

If the police are asked to help, there is a 33% chance the band will make the gig on time.

If the site management alters the road system, the set will be 40 minutes shorter.

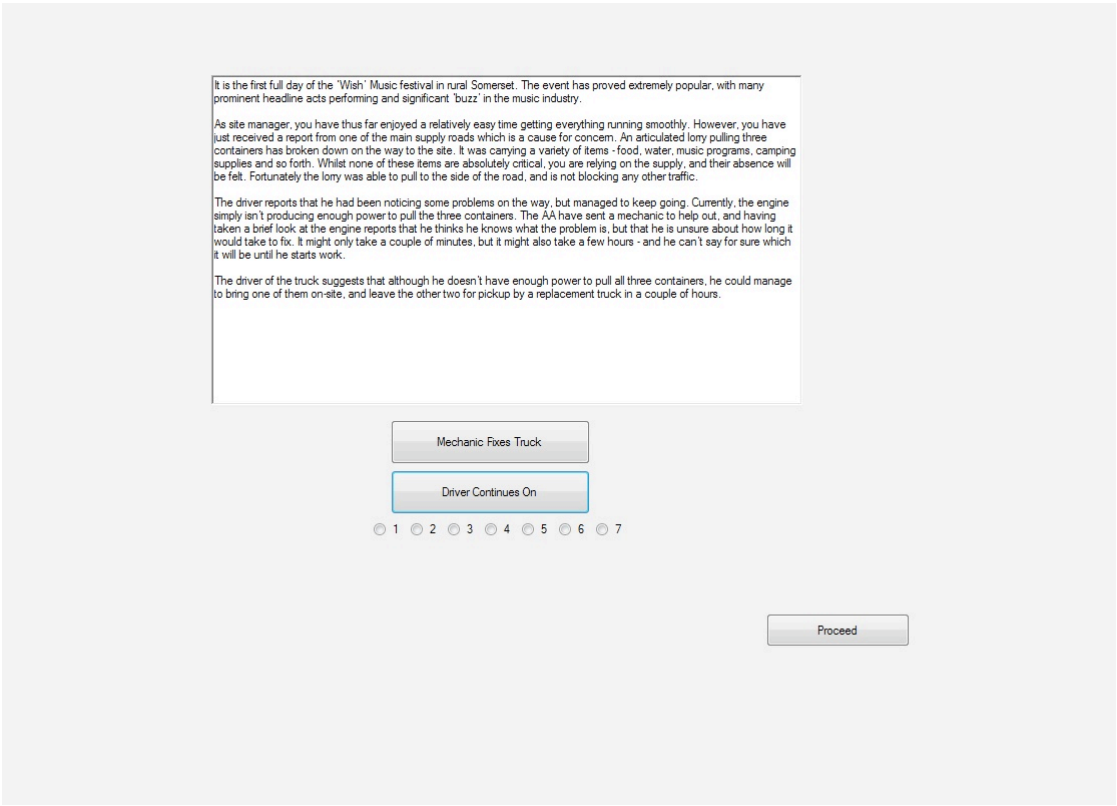
Fourteen: Festival Study Qualitative Feedback Pattern and Values

		Money		Reputation	
Question	**Decision**	*Internal*	*External*	*Internal*	*Externa*
1	Water Pipe	Small Gain	Small Gain	Small Gain	Small Gai
2	First Outbreak	Small Gain	Small Loss	Small Gain	Small Los
3	Band Delay	Medium Loss	Medium Gain	Slight Loss	Slight Gai
4	Medical Evac	Large Gain	Large Loss	Medium Gain	Medium Los
5	Case Spike	Medium Loss	Medium Gain	Medium Loss	Medium Gai
6	Rumours	Medium gain	Medium Loss	Small Gain	Small Los
7	Food Poisoning	Very Large Loss	Large Loss	Medium Loss	Medium Gai
8	Small Riot	Large Loss	Very Large Loss	Medium Gain	Medium Los
9	Leaving Early	Medium Loss	Medium Gain	Large Loss	Large Gai
10	Diagnosis	Medium Gain	Medium Loss	Large Gain	Large Los
11	Treatment	Medium Loss	Medium Gain	Small Loss	Small Gai

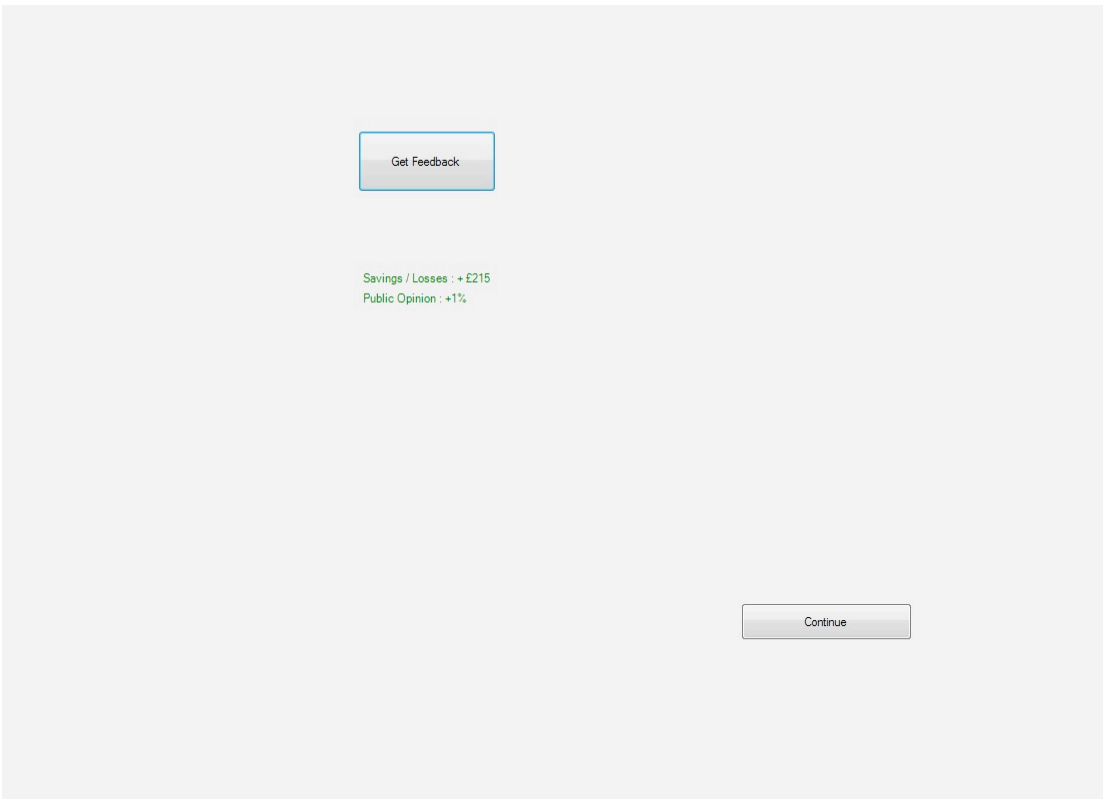
Fifteen: Festival Study Numeric Feedback Pattern and Values

		Money		**Reputation**		**Cases**	
Question	**Decision**	*Internal*	*External*	*Internal*	*External*	*Internal*	*External*
1	Water Pipe	215	215	1	1	0	0
2	First Outbreak	765	-765	1	-1	0	0
3	Band Delay	-1892	1892	-1	1	15	15
4	Medical Evac	4004	-4004	2	-2	0	2
5	Case Spike	-872	872	-2	2	3	3
6	Rumours	1756	-1756	1	-1	20	20
7	Food Poisoning	-15,472	-8765	-2	2	4	2
8	Small Riot	-8801	-15563	2	-2	3	5
9	Leaving Early	-4037	4037	-3	3	4	2
10	Diagnosis	2356	-2356	3	-3	8	12
11	Treatment	2405	2405	-1	1	23	19

Sixteen: Festival Study Decision Page Screenshot



Seventeen: Festival Study Feedback Page Screenshot



Eighteen: Herbal Study Alternative Therapies attitude questionnaire

The task you are about to undertake involves making purchasing decisions in the context of alternative medicine. Please take a moment to answer the following questions on that topic.

Answer the following on the sheet provided on a scale of 1-5, with 5 being 'strongly agree', 1 being 'Strongly disagree' and 3 as 'Neutral/Unsure'

1) Alternative medicines can provide real therapeutic effects

2) Alternative medicine contains systems equal in value to that of conventional medicine.

3) Conventional medicine is better than Alternative medicine.

4) Alternative medicine has no merit

5) People should be free to use alternative medicine, if they choose to

6) Alternative medicine should be available on the NHS

7) There is a lot we can potentially learn from alternate medicinal systems

8) Alternative medicine is a poor substitute for conventional medicine

9) Alternative medicine is no better than a fraud.

10) People who sell alternative medicines are doing something morally objectionable.

11) Alternative medicine can be used in conjunction with conventional medicine for additional therapeutic benefit.

Please answer the following simply yes/no:

12) Have you, or anyone you are close to, made use of an alternative therapy?

13) Do you think Alternative Therapies can be effective?

14) Would you recommend any alternative therapies to a friend?

Nineteen: Herbal Study Social Media Questionnaire

Please answer the following questions yes/no, or otherwise as indicated.

1) Would you say you are familiar with what 'social media is?'
2) Do you have a 'social media account' of any type (twiter, facebook, linkedin etc)?
3) If so, how many different ones do you have (approximately)
4) How often would you say you check a social media site of any type?

   (Several times a day/Daily/a few times a week/once a week/rarely)
5) Are you familiar with Twitter specifically (what it does, how it works)?
6) Do you have a twitter account?
7) If yes, how often would you say you check your twitter?

   (Several times a day/Daily/a few times a week/once a week/rarely)
8) Are you comfortable with reading a twitter 'feed' as a source of news etc?
9) Please rank the following in terms of where you feel you get the majority of your news from:

   Online (news sites)
   Online (Social media etc)
   TV
   Newspapers
   Word of mouth
   Radio
10) Overall, how important would you say that social media is to your everyday life – personal, professional or otherwise?
    (Essential/Very important/Useful/Sort of important/Unimportant)

Twenty: Herbal Study Instructions

In this task you will be taking on the role of a buyer for a medium sized group of co-operative shops. Although your duties cover a range of products, the task you will be asked to undertake will focus on your purchasing of alternative medicines and specifically herbal remedies.

Alternative medicines – remedies that exist outside the framework of conventional scientific process – have been growing in popularity greatly over the last decade, and many people now use them for everything from skin conditions to treating depression.

As a buyer for a cooperative, you hold a responsibility for a large number of privately held and operated stores, who buy in bulk as a group and then sell these remedies as part of their business. It is your job to balance the various factors that may come into play and obtain products for which there is high demand, a competitive price, can be reliably supplied, etc. Note that it is not your job to judge efficacy of the products, but rather aim to meet the demand that exists!

Over the last few years you have developed links with two companies who are in direct competition with each other and supply many of the same products. It is your task to choose which company you will order your products off for that particular month. The two companies are:

Astor Remedies – a company located in the small central Asian country of Aplonia that boasts local production and 'ancient cultural wisdom' as the basis for its products.

Quetia – a company based in the first-world antipodian country of Yokovia which claims to make the most of modern production techniques for these old ideas.

For each decision you will be given the situation as it is understood by the media, and also a snapshot of your twitter feed on that day. You have chosen a range of people to 'follow', each of whom is a person of interest in the area (shopkeeper, journalist, avid user etc) and are sharing their thoughts on the issues of the day.

In addition to choosing which company you wish to order from, you will also be asked to rate your confidence in this decision, from 1 (little or no confidence) to 7 (high or absolute confidence). After each decision you will be presented with feedback on how your choice has impacted sales and shopkeeper confidence. After each decision has been made, you will then receive feedback about your performance, in the form of an overall sales report, and also the general opinions of the retailers you serve.

Each of these areas (tweets, decision, choice making) are hidden whilst the others are being viewed. You may, however, switch back and forth between the sections for as long as you like, and as many times as you like.

All the decisions you make have the potential to affect the future decisions you face and have consequences later on, and should therefore be approached tactically. Additionally, there is an element of random chance to the outcome of

these decisions and how well they go: you can maximize your *chance* of success, but cannot *guarantee* it. As in real life, sometimes things may go wrong even if you make all the right decisions.

Twenty-One: Herbal Study Feedback Pattern and Values

Question	*Decision*	*Correct*	**Astor** *Money*	*Opinion*
1	First Choice	Either	Small Gain	Small Gain
2	Miraclo Shipping	Astor	Small Gain	Medium Gain
3	Child labour	Quetia	Medium Loss	Small Loss
4	Yok regulating	Astor	Medium Gain	Small Gain
5	Glass	Quetia	Small Loss	Small Gain
6	Internal Q	Astor	Medium Gain	Medium Gain
7	Takeover	Quetia	Small Gain	Medium Loss
8	MP	Astor	Large Gain	Small Gain
9	Container	Quetia	Medium Loss	Small Loss
10	GP letters	Astor	Medium Loss	Small Loss

			Astor		Quetia	
Question	*Decision*	*Correct*	*Money*	*Opinion*	*Money*	*Opinion*
11	Products returned	Quetia	Large Loss	Medium Loss	Medium Loss	Small Loss
12	PR initiatives	Astor	Small Gain	Medium Gain	Small Loss	Small Gain
13	Parliament	Quetia	Small Loss	Small Gain	Small Gain	Medium Gain
14	Offers	Astor	Small Loss	Small Gain	Small Gain	Small Loss
15	Enquiry due	Quetia	Small Gain	Small Loss	Small Loss	Small Gain
16	Final decision	Either	Medium Gain	Medium Gain	Medium Gain	Medium Gain

Twenty-Two: Herbal Study sample decision

Decision 2

In the last month, there has been a flurry of interest in a new product derived from a special type of flower. It is said to make a person more consistently aware and awake, as well as boosting intelligence. Students, doctors and other high-intensity groups have been showing a distinct interest in the substance, known as 'Miraclo'.

Both companies you are engaged with have started to put very similar forms of this product into production, and are offering it as a purchase option this month. The main concern at this point is in the viability of getting this product delivered and onto shelves in time to capitalize on the current wave of publicity being generated by magazines and TV shows.

Astor, located in Aplonia is closer to your shops by several hundred miles and expect to delivery quickly. However, much of its distribution network relies heavily on trucks and road transport which are known to be occasionally unreliable thanks to the country's infrastructure and government corruption which sometimes hold up shipments significantly and unpredictably.

Quetia do not have this issue, as the country is a full functioning first-world economy, however they ship their products primarily by sea in order to keep down costs and remain competitive. Their delivery time is guaranteed, but at a non-trivially longer timeframe than the optimal estimates from Astor.

Twenty-Three: Herbal Study Sample Tweets, Neutral Decision 2

Crystal_zs Crystal
How many cups of tea is it ok to have in a morning?
3 minutes ago

MaddieScott Maddie Scott
Acupunture may be a growth product next year, these things are cyclic
5 minutes ago

AltMedicineUK Alt Medical News
Miraclo gets a mention on 'Daybreak' : http://Bit.ly/GGWe1
9 minutes ago

Shiney163 Shiney!
There's nothing better in life than a walk with my dog.
9 minutes ago

BobtheBob_B Robert
Anyone hear about this new Miraclo thing? Actually tried it?
10 minutes ago

Twenty-Six: Herbal Study Sample Tweets, Pro-Astor Decision 2

Crystal_zs Crystal
I'm excited for this new Miraclo product! Want it now!
2 hours ago

MaddieScott Maddie Scott
I'd rather get Miraclo a little late but reliably - uncertainty kills me for stocktaking.
2 hours ago

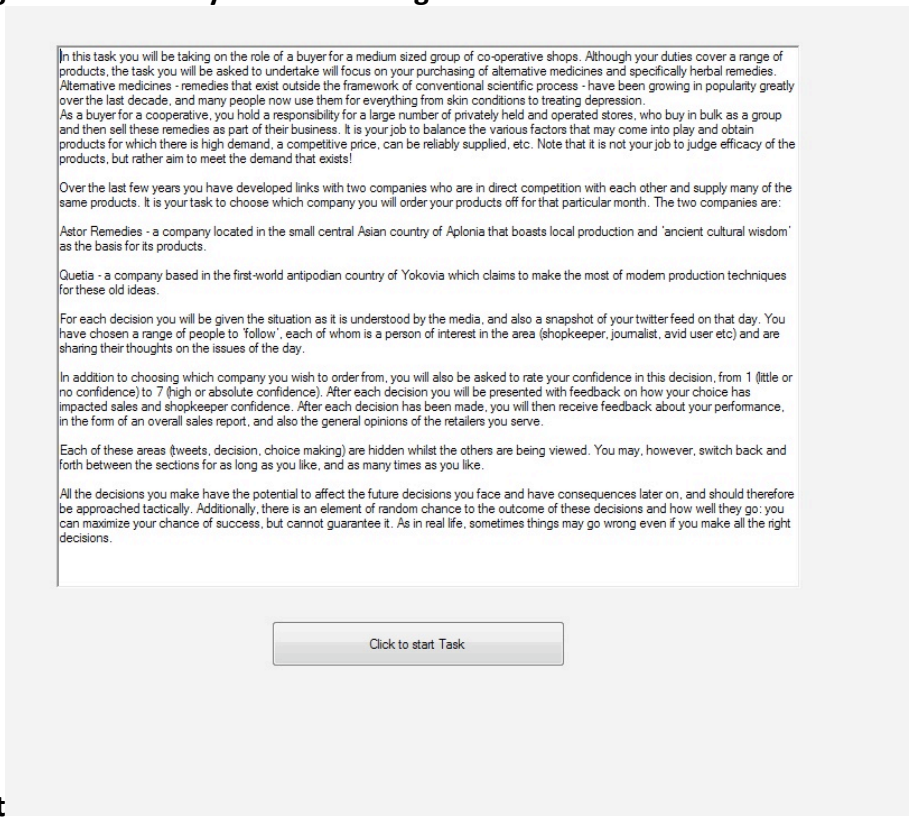
AltMedicineUK Alt Medical News
Miraclo gets a mention on 'Daybreak' : Bit.ly/GGWe1
2 hours ago

Shiney163 Shiney!
I'm going to give miraclo if I can find somewhere that has it right now...
2 hours ago

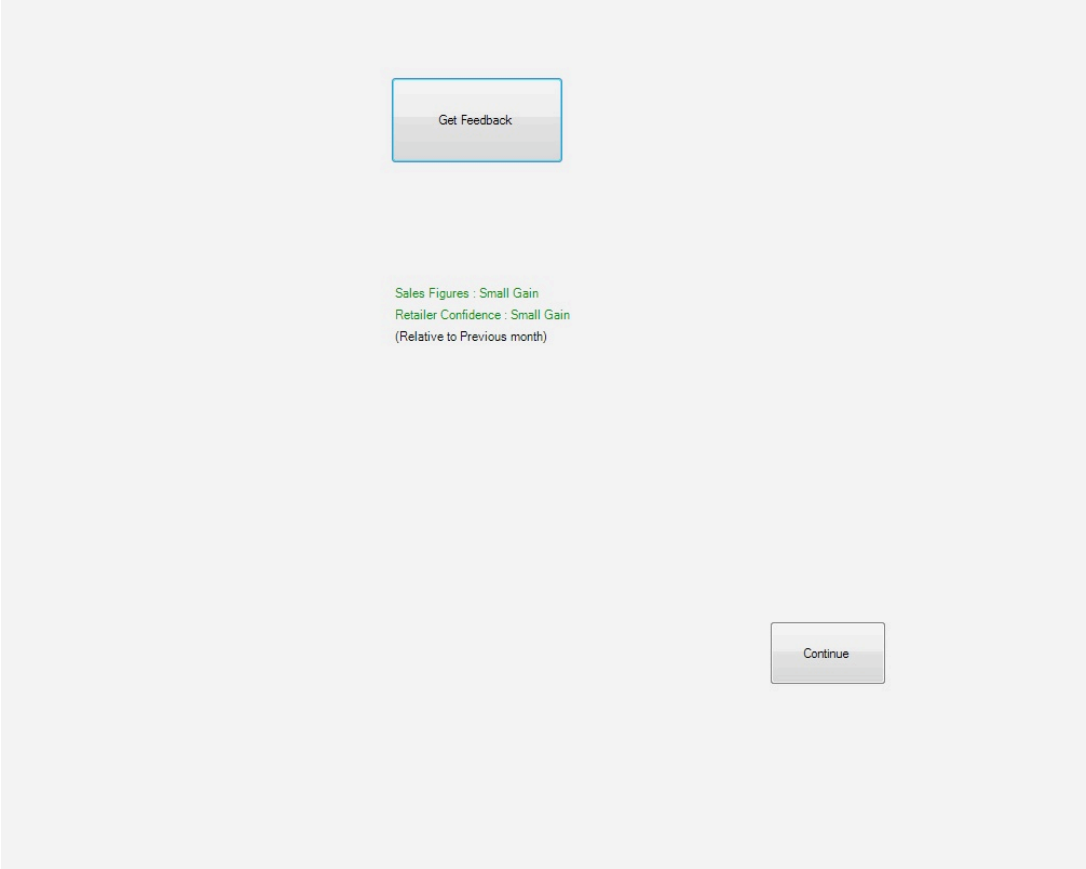
BobtheBob_B Robert
Miraclo is hot NOW - we need packets on shelves now people! Who knows how long this'll last?
2 hours ago

Twenty-Four: Herbal Study Sample Tweets, Pro-Quetia Decision 2

Twenty-Eight: Herbal Study Instruction Page Screenshot



Twenty-Five: Herbal Study Sample Feedback Screenshot



Twenty-Six: Herbal Study Event Text

----Breaking News----

Over the last three days a great number of people have been taken ill across the country with severe digestive and respiratory problems. Cases have been reported in areas as far apart as Exeter in the Southwest, Newcastle in the Northeast and Nottingham in the center of the country.

Although it was not immediately clear what the problem was, consultation with patients families and coordination between various health authorities have identified that 90% of cases can be directly correlated with the victims having taken Miraclo in the last few days. Subsequent tests on the bottles of this substance found at the houses of patients have revealed consistent levels of industrial fertilizer, waste products and rat poison. Bottles of both Astor and Quetia marked products have been discovered to be contaminated as a result. Strangely, the two show different types of contamination between the two companies, but consistency within a given company's product.

As a result of this discovery, an emergency healthy warning has been issued by the government, with people advised to dispose of all of these products they have, regardless of manufacturer or location they were bought from. All sales of the substance have been banned, and stock removed from shelves across the country. The government has also ruled out the possibility of this being a terrorist or malicious attack of any sort.

Details are still trickling through, but in an effort to track the source of the problem, both Astor and Quetia products have been identified as causal factors. Both companies are insisting that this is the result of fraudulent knock-off products that they are not responsible for, although there are some suggestions that there was contamination within regular shipments too.

Astor Framed text:

Currently doctors say that they have been able to save 1/3 of the patients that took Astor products. However, there is a 66% chance that the patients who took Quetia products will suffer sever long-term health issues and disabilities.

Quetia Framed text:

Currently doctors say that they have been able to save 1/3 of the patients that took Quetia products. However, there is a 66% chance that the patients who took Astor products will suffer sever long-term health issues and disabilities.